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Geology of

Carbonatite – Alkalic Rock Complexes in Ontario:

Killala Lake Alkalic Rock Complex

District of Thunder Bay

Ontario Geological Survey
Study 45

by R. P. Sage

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Foreword

The Killala Lake Alkalic Rock Complex was examined as part of a project to study alkalic rock – carbonatite complexes in Ontario. The study describes the rock types and mineralogy of the complex and outlines the history of the mineral exploration efforts within the complex.

V.G. Milne

Director
Ontario Geological Survey

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CHART (back pocket)

Chart A (coloured) — Figure 3.

CONVERSION FACTORS FOR MEASUREMENTS IN ONTARIO GEOLOGICAL SURVEY PUBLICATIONS

Conversion from SI to Imperial			Conversion from Imperial to SI		
SI Unit	*Multiplied by*	*Gives*	*Imperial Unit*	*Multiplied by*	*Gives*
		LENGTH			
1 mm	0.039 37	inches	1 inch	**25.4**	mm
1 cm	0.393 70	inches	1 inch	**2.54**	cm
1 m	3.280 84	feet	1 foot	**0.304 8**	m
1 m	0.049 709 7	chains	1 chain	20.116 8	m
1 km	0.621 371	miles (statute)	1 mile (statute)	**1.609 344**	km
		AREA			
1 cm^2	0.155 0	square inches	1 square inch	**6.451 6**	cm^2
1 m^2	10.763 9	square feet	1 square foot	**0.092 903 04**	m^2
1 km^2	0.386 10	square miles	1 square mile	2.589 988	km^2
1 ha	2.471 054	acres	1 acre	0.404 685 6	ha
		VOLUME			
1 cm^3	0.061 02	cubic inches	1 cubic inch	**16.387 064**	cm^3
1 m^3	35.314 7	cubic feet	1 cubic foot	0.028 316 85	m^3
1 m^3	1.308 0	cubic yards	1 cubic yard	0.764 555	m^3
		CAPACITY			
1 L	1.759 755	pints	1 pint	0.568 261	L
1 L	0.879 877	quarts	1 quart	1.136 522	L
1 L	0.219 969	gallons	1 gallon	**4.546 090**	L
		MASS			
1 g	0.035 273 96	ounces (avdp)	1 ounce (avdp)	28.349 523	g
1 g	0.032 150 75	ounces (troy)	1 ounce (troy)	**31.103 476 8**	g
1 kg	2.204 62	pounds (avdp)	1 pound (avdp)	**0.453 592 37**	kg
1 kg	0.001 102 3	tons (short)	1 ton (short)	**907.184 74**	kg
1 t	1.102 311	tons (short)	1 ton (short)	**0.907 184 74**	t
1 kg	0.000 984 21	tons (long)	1 ton (long)	**1016.046 908 8**	kg
1 t	0.984 206 5	tons (long)	1 ton (long)	**1.016 046 908 8**	t
		CONCENTRATION			
1 g/t	0.029 166 6	ounce (troy)/ ton (short)	1 ounce (troy)/ ton (short)	34.285 714 2	g/t
1 g/t	0.583 333 33	pennyweights/ ton (short)	1 pennyweight/ ton (short)	1.714 285 7	g/t

OTHER USEFUL CONVERSION FACTORS

1 ounce (troy) per ton (short)	20.0	pennyweights per ton (short)
1 pennyweight per ton (short)	0.05	ounces (troy) per ton (short)

Note: Conversion factors which are in bold type are exact. The conversion factors have been taken from or have been derived from factors given in the Metric Practice Guide for the Canadian Mining and Metallurgical Industries, published by the Mining Association of Canada in cooperation with the Coal Association of Canada.

Geology of
Carbonatite – Alkalic Rock Complexes in Ontario:
Killala Lake Alkalic Rock Complex
District of Thunder Bay

R.P. Sage[1]

1. Geologist, Precambrian Geology Section, Ontario Geological Survey, Toronto. Manuscript approved for publication by John Wood, Chief Geologist, Ontario Geological Survey, December 19, 1983.

This report is published with the permission of V.G. Milne, Director, Ontario Geological Survey.

Abstract

The Killala Lake Alkalic Rock Complex is one of several complexes that define an alkalic rock–carbonatite petrogenetic province north of Lake Superior. The complex has been dated by Rb–Sr techniques at approximately 1050 ± 35 Ma. The intrusive body consists of a silica–saturated syenite core, an olivine gabbro rim and a nepheline syenite unit between the gabbro and syenite. A minor unit of larvikite is associated with the gabbros on the west and east sides of the complex and a horseshoe shaped body of nepheline monzonite occurs within the core of the complex.

The intrusion lies at the intersection of regional fractures and may possibly have a southwest plunge. The present level of exposure provides an oblique cross section through the body with the northern part displaying textural and structural features characteristic of high level emplacement. The large tear–drop shaped mass of syenitic rock extending north from the complex is probably a relatively thin sheet–like body.

Widespread disseminated sulphide mineralization is associated with the gabbro rim and contains minor copper and nickel values. The mineralized gabbro warrants testing for platinum group metals. Minor pyrochlore (niobium) occurs in pegmatitic phases of the syenite.

Résumé

Le complexe rocheux alcalin du lac Killala fait partie des complexes qui définissent une province pétrogénétique composée de roches alcalines et de carbonatite et située au nord du lac Supérieur. D'après les techniques isotopiques de datation au Rb–Sr, l'âge du complexe est de 1050 ± 35 Ma. L'intrusion est formée d'un noyau de syénite saturée de silice, d'une frange de gabbro à olivine et d'une unité de syénite néphéline située entre le gabbro et la syénite. Une petite unité de laurvickite est associée aux gabbros des côtés ouest et est du complexe. Le noyau du complexe comprend une formation de monzonite néphéline en forme de fer à cheval.

L'intrusion est située à l'intersection de fractures régionales et pourrait se prolonger vers le sud–ouest. L'affleurement actuel offre une coupe transversale oblique. La texture et les caractéristiques de la partie nord sont typiques aux intrusions de ce niveau. L'importante masse de roche syénitique en forme de larme au nord du complexe est sans doute une mince formation stratiforme.

Une vaste minéralisation disséminée de sulfure est associée à la frange de gabbro et elle est peu riche en cuivre et en nickel. En raison de la présence de gabbro minéralisé, on devrait déterminer si le complexe est riche en mine du platine. On trouve un peu de pyrochlore (niobium) dans les phases pegmatitiques de la syénite.

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Introduction

The Killala Lake complex was examined in 1975 as part of a project to study alkalic rock – carbonatite complexes. The Killala Lake alkalic rock complex is tear–drop shaped in plan view and ranges in composition from gabbro to syenite. The various lithologic units have a concentric spatial distribution from gabbro rim to syenite core, with the core rocks being younger than those of the rim. The intrusive complex sharply crosscuts the regional trends of the enveloping Early Precambrian schists and granitic rocks. The emplacement of the complex was controlled by a regional north–trending fracture which, projected northward, also controls the emplacement of the Chipman Lake carbonatite dikes and fenites. The southern extension of the fracture joins with the Port Coldwell Alkalic Rock Complex. Petrographic examination of samples collected from the complex shows the ubiquitous presence of kelyphytic rims on the primary mineral phases, suggesting disequilibrium between the primary phases and late stage liquids. Late stage autometamorphic or deuteric effects were extensive and pervasive throughout the complex.

The syenites of the core do not appear to have mineralization of potential economic interest. The peripheral nepheline syenites may contain zones which could be of economic value for their nepheline content. Disseminated interstitial sulphides associated with the rim gabbros have been tested for their copper and nickel potential. This work has disclosed minor but widespread sulphide mineralization at three widely spaced locations. Additional testing for copper–nickel values appears warranted and the possible presence of platinum group metals should be investigated.

Acknowledgments

Air support was supplied to the field party by Geraldton Fire Control of the Ministry of Natural Resources, Mr. J.K. Cleavely, Manager. Mr. Wilf Belisle, Field Services Superintendent, and Mr. Don McNabe, pilot of the Ministry of Natural Resources, made special efforts to ensure prompt and accurate resupply to the party. The Ministry of Natural Resources, Geraldton, also loaned various equipment to the field party which greatly aided mapping. The staff of the Regional Fire Control provided the party with regular communications.

Mr. D. Bathe, senior geological assistant, mapped the periphery of the complex. Mr. Bathe and the author were assisted in their work by Mr. W. Wright, Mr. P. Chamois, and Mr. K. Shewbridge. Mr. W. Wright mapped the southern half of Papaver Lake. In 1988, the statistical compositions (Appendix A) were recalculated by Mr. A. Lisowyk and the chemical data revised.

Location and Access

The Killala Lake Alkalic Rock Complex (Figure 1) is located approximately at 49°11'N Latitude and 86°27'W Longitude, about 56 km north of Marathon. Access to the main part of the complex is by float–equipped aircraft to any of the five larger lakes in the area: Killala, Sandspit and Kagiano, located respectively along the southwest, west, and northwest flanks of the complex; Kentron Lake located within the centre, and a small unnamed lake 3.2 km east of the north end of Killala Lake. The northeast, east, and southeastern flanks are accessible only by very long traverses or helicopter. Difficulty in reaching these parts of the complex has hindered detailed mapping.

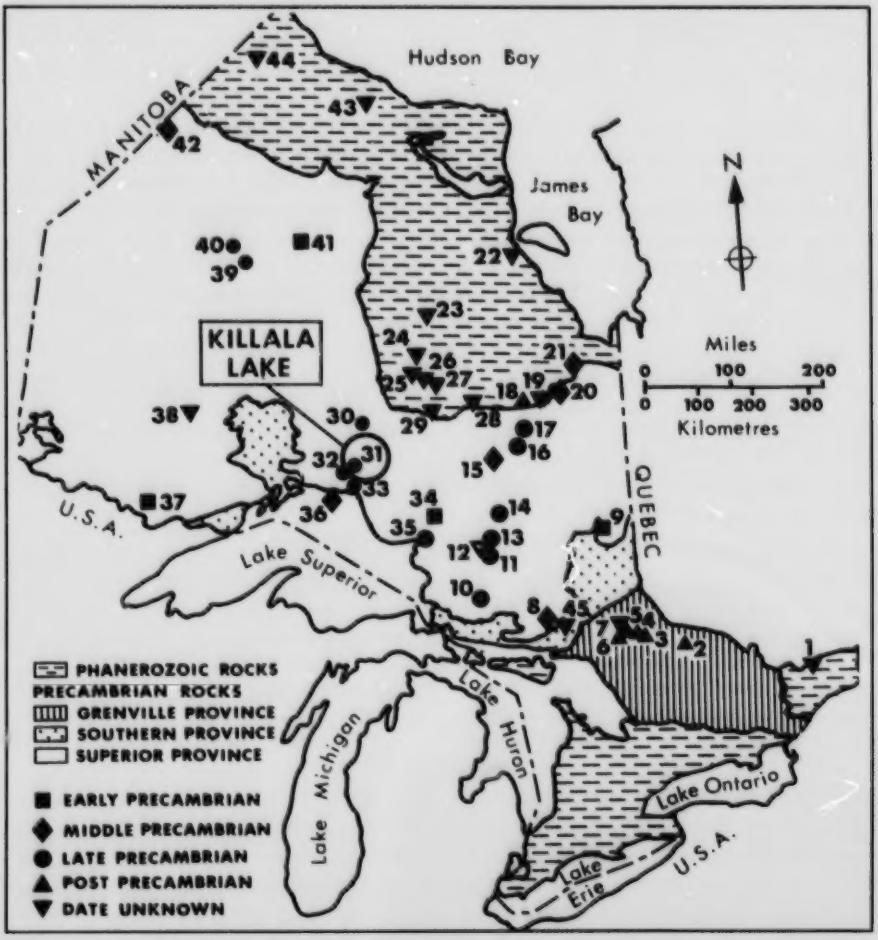


Figure 1. *Key map showing location of carbonatite - alkalic rock complexes in Ontario.*

1. *Eastview*
2. *Brent*
3. *Callander B.*
4. *Manitou Is.*
5. *Burritt Is.*
6. *Iron Is.*
7. *Lavergne*
8. *Spanish R.*
9. *Otto Stock*
10. *Seabrook L.*
11. *Lackner L.*
12. *Borden Tp.*
13. *Nemegosenda L.*
14. *Shenango Tp.*
15. *Cargill Tp.*
16. *Teetzel Tp.*
17. *Clay-Howells*
18. *Hecla-Kilmer*
19. *Valentine Tp.*
20. *Goldray*
21. *Argor*
22. *Lawashi R.*
23. *Poplar R.*
24. *Albany Forks*
25. *L. Drowning R.*
26. *Kingfisher R. West*
27. *Kingfisher R. East*
28. *Martison L.*
29. *Nagagami R.*
30. *Chipman L. (dikes)*
31. **Killala L.**
32. *Prairie L.*
33. *Port Coldwell*
34. *Herman L.*
35. *Firesand R.*
36. *Slate Is.*
37. *Poohbah L.*
38. *Sturgeon Narrows & Squaw L.*
39. *Schryburt L.*
40. *Big Beaver House*
41. *Wapikopa L.*
42. *"Carb" L.*
43. *Gooseberry Br.*
44. *Niskibi L.*
45. *Nemag L. & Lusk L.*

Field Methods

Mapping of the area was plotted on acetate overlays on airphotos at a scale of 1:15 840, supplied by the Airphoto Library, Ministry of Natural Resources. The data from the acetate overlays were then transferred to a base map at the same scale, supplied by the Lands and Water Group, Ministry of Natural Resources. Previously published government reports and the files of the Assessment Files Research Office, Ontario Geological Survey, Toronto, were consulted to determine exploration history for the area.

Previous Geological Work

Coates (1967) completed an M.Sc. study of rocks of the complex and a synopsis of this work was published as part of a broader geologic survey (Coates 1970). As part of the study of alkalic rock – carbonatite complexes by the Ontario Geological Survey, a geochemical survey of a portion of the complex was undertaken by L.G. Closs in 1975. Samples collected during the geochemical survey served as a base for a petrographic study completed by P. Wanless (1976) for a B.Sc. thesis.

The author (Sage 1976) published a preliminary geological map of the complex based on field observations. Bathe (1977) completed a B.Sc. thesis on samples collected during the geological survey. Bell and Blenkinsop (1980) completed a Rb–Sr isochron age on samples collected by the field party during mapping of the complex in 1975. Selected additional references that have appeared in the literature were added during final editing in 1988.

Physiography

The complex has a surface area of approximately 110 km^2. The complex forms a series of high arcuate hills which rise 170 m or more above the surrounding, generally flat to gently rolling, terrain. Within the complex, relief is locally on the order of tens of metres and cliff faces over 30 m are not uncommon. The rugged terrain makes lengthy traverses difficult.

Bedrock exposures are generally relatively abundant even though glacial and boulder till locally mask the bedrock. The syenitic and gabbroic rocks are deeply weathered, making the gathering of fresh rock samples difficult.

Laboratory Techniques

At the conclusion of mapping, the freshest samples obtainable from the complex were selected for thin sectioning and complete rock analysis. All thin sections from those samples selected for analysis were stained for potassium feldspar. This staining disclosed a complex arrangement of the various feldspar minerals that would not be normally observable. Staining, however, has obscured nepheline and colour tinted various minerals and has masked or modified other features. The accompanying map (see Figure 3, Chart A) has been modified on the basis of petrographic and chemical data.

Nomenclature

Nomenclature used in mapping alkalic rock – carbonatites of Ontario is modified after that of Parsons (1961). The author has used a somewhat different nomenclature in the present report, in conformity with the nomenclature used in describing other alkalic rock – carbonatite complexes in northern Ontario. For the alkalic rocks, the author prefers to use mineralogic, colour, or textural modifiers, which are familiar to all readers, rather than unfamiliar rock names. Alkalic rock

nomenclature is cumbersome, due in large part to the profusion of unfamiliar rock names. Consequently, as an aid to the reader, the use of less familiar rock names will be limited. The rock terms retained by the author and the way they are used are given below.

Ijolite. A nepheline–pyroxene rock with a nepheline content between 30 and 70%. Rocks containing more than 70% nepheline are classified as urtite and those with less than 30% as melteigite. Some specimens may contain significant amounts of biotite in place of pyroxene. Potassium feldspar content is 10% or less and those rocks with 10% or less nepheline are classified as pyroxenite.

Malignite. A melanocratic nepheline syenite. In general, nepheline, pyroxene and potassium feldspar occur in roughly equal proportions. The potassium feldspar content must exceed 10% or the rock is classified as belonging to the ijolite suite. Both the nepheline and pyroxene content must exceed 10% or the rock would be classified with the syenites. This rock group is transitional between the ijolites and overlaps the syenitic rock groups.

Sovite. A carbonatite rock composed of 50% or more calcite. Various mineralogic modifiers are used to classify the sovite, for example, apatite–magnetite sovite, olivine–amphibole sovite, etc.

Silicocarbonatite. A carbonate–rich rock containing 50% or more oxide and silicate minerals. Where the silicate or oxide minerals make up more than 90% of the rock, various other rock names are applied, i.e., ijolite, biotite, pyroxenite, etc.

Syenite. This term is restricted to a quartz–free rock consisting primarily of alkali feldspars. Various mafic minerals and nepheline may be present and form a significant component of the rock. The syenites are named on the basis of their mineralogy, i.e., pyroxene nepheline syenite, biotite amphibole syenite, etc. The syenites are gradational into malignites.

There is no standard subdivision of the ijolite suite into ijolite, urtite, and melteigite. Bailey (1974) classified urtites as having more than 70% nepheline, however he used the term ijolite to apply only to those rocks containing between 50 and 70% nepheline. The author finds this range to be too restricted for field use and prefers the 30 to 70% range given by Williams *et al.* (1954, p.70).

Malignite from the Poohbah Lake Complex in northwestern Ontario was originally defined by Lawson (1896) as an alkali–rich rock containing pyroxene, and potassium feldspar, with or without nepheline, garnet and amphibole. The author has examined the malignite of this complex in the field and in a large number of thin sections. The malignites are melanocratic and contain pyroxene, nepheline, orthoclase, garnet, and amphibole. The nepheline content of the type location is relatively low compared with the definition given above. For field work and to better emphasize the gradational nature of malignite into ijolites and syenites without the use of cumbersome terminology, a broader usage of the term has been applied by the author. Williams *et al.* (1954, p.65–66)described a number of malignites of varying mineralogy.

The Poohbah Lake type location for malignite was re–investigated by Mitchell and Platt (1978) and malignite was redefined by them as a nepheline syenite containing oikocrystic potassium feldspar. The author considers the definition of Mitchell and Platt too restrictive. The term malignite is used by the author for a melanocratic nepheline syenite as defined by Sorensen (1974, p.27).

The definitions of sovite and silicocarbonatite are modified from Heinrich (1966, p.12). The author has found Heinrich's subdivision of the carbonate–rich

carbonatitic rocks generally suitable for field usage when modified to a two–fold subdivision at about 50% oxide and silicate mineral contents. The two–fold subdivision is more convenient than the four–fold subdivision of Heinrich (1966) because carbonatites show extreme variations in mineral content over distances of less than a few centimetres. It is difficult to rigorously classify such heterogeneous rocks.

General Geology

The Killala Lake Alkalic Rock Complex (Figure 2 and Figure 3, Chart A, back pocket) is well outlined on aeromagnetic maps (ODM–GSC 1963a,b). The geology has been previously described by Coates (1967, 1970). The complex consists of arcuate to almost completely circular units distributed from the rim of the complex towards the core in a systematic pattern of gabbro, nepheline syenite, and syenite. The lithologic sequence (Table 1) reflects an increasing silica content and decreasing age towards the core of the complex.

The gabbro is cut by, and also commonly occurs as large xenolithic blocks within, the nepheline syenites. The contact between gabbro and syenitic rock is sharp and angular and there is little evidence of reaction of the gabbroic inclusions with the intruding syenitic magma.

Figure 2. *Aeromagnetic map of the Killala Lake Alkalic Rock Complex. From aeromagnetic maps 2148G, 2158G (ODM–GSC 1963a,b).*

TABLE 1. TABLE OF LITHOLOGIC UNITS FOR THE KILLALA LAKE ALKALIC ROCK COMPLEX.

CENOZOIC

Recent

Stream, lake and swamp deposits.

Pleistocene

Glacial deposits, boulders, gravel, sand, silt.

Unconformity

LATE PRECAMBRIAN (PROTEROZOIC)

Killala Lake Alkalic Rock Complex

Dike Rocks

Feldspar-porphyritic syenite; lamprophyre; intrusive breccia.

Intrusive Contact

Syenitic Rocks

Inner Red-Brown Syenite

Bright red to rusty brown syenite; red syenite dikes.

Gradational Contact

Inner Buff Syenite

Coarse-grained syenite; mafic (amphibole) syenite.

Gradational Contact

Outer Nepheline Syenite

Nepheline syenite; hornblende syenite; cancrinite syenite; nepheline syenite pegmatite.

Intrusive Contact

Nepheline Monzonite to Monzonite*

Monzonite with olivine and nepheline; monzonite; contact facies of monzonite.

Intrusive Contact

Gabbroic Rocks*

Larvikite

Larvikite (augite + alkali feldspar).

Gabbro

Olivine gabbro; troctolite (olivine + plagioclase + minor augite); gabbro.

Intrusive Contact

Mafic Dike Rocks

Diabase, porphyritic diabase; lamprophyre, olivine-rich lamprophyre.

Intrusive Contact

EARLY PRECAMBRIAN (ARCHEAN)

Felsic Intrusive Rocks

Late Potassic Granitic Rocks

Quartz monzonite to granodiorite.

Early Trondhjemitic Rocks

Gneissic trondhjemite to granodiorite; quartz monzonite pegmatite.

Intrusive Contact

Metasediments

Biotite-quartz-plagioclase schist and hornfels;
hornblende-biotite-quartz-plagioclase schist and hornfels; amphibolite.

*Age relationships between these two units are unknown.

The buff to grey nepheline syenite found along the margins of the complex is gradational into similar (in colour and grain size) syenites lacking nepheline, which, in turn, are gradational into nepheline–absent dark red to brown syenite. The darker red to brown syenites are in turn gradational into syenitic rocks that display highly variable textures and xenolithic inclusions. Even though the various syenitic rocks appear to be gradational into each other in a systematic fashion from periphery to core, the various phases will lie in sharp contact with each other if one of the intervening phases is absent from the sequence. For example: in several places at the northern side of the complex, nepheline syenite was observed to be in sharp contact with the dark–coloured red to brown syenite where the usual transitional buff coloured nepheline–deficient unit was absent.

Within the centre of the complex, a horseshoe–shaped body of predominantly porphyritic rock was previously described by Coates (1970) as olivine–nepheline syenite and was considered by him to be younger than the surrounding syenites. This body has locally been extensively intruded by dikes of the enclosing syenites, suggesting that it is an older phase of alkaline magmatism and not a younger phase as suggested by Coates (1970). Chemically this unit is analogous to alkalic monzonite (see Appendix A).

The larvikite described by Coates (1970) appears by its spatial distribution in the field to be a coarse–grained, feldspar–rich phase of the gabbro. Elongate, coarse–grained, feldspar–rich segregations with diffuse contacts, and very similar in appearance to the larvikite, were noted in several hand samples of gabbro collected along the western margin of the complex, implying a possible connection between the two lithologies. Chemically the larvikite (column 4, Table 2) is as close to Nockold's monzonite (column 1) in composition as it is to Nockold's larvikite (column 2) and its chemistry is also similar to the horseshoe–shaped body of nepheline monzonite to monzonite (column 5) found within the centre of the Killala Lake complex. Contact relations between the larvikite unit and the gabbro were not observed so the relationship of this unit to the gabbro is unclear.

TABLE 2. MAJOR ELEMENT COMPOSITION OF KILLALA LAKE LARVIKITE AND MONZONITE COMPARED WITH SOME ALKALIC ROCKS FROM NOCKOLDS (1954).

	1.	2.	3.	4.	5.
SiO_2	55.36	57.01	50.38	55.60	54.67
TiO_2	1.12	1.67	2.49	1.41	0.76
Al_2O_3	16.58	17.88	19.97	15.73	17.83
Fe_2O_3	2.57	2.30	2.77	5.50	3.69
FeO	4.58	4.18	3.96	5.46	4.56
MnO	0.13	0.14	0.13	NM	NM
MgO	3.67	1.54	2.15	1.17	1.87
CaO	6.76	4.39	6.01	4.32	4.78
Na_2O	3.51	5.80	6.25	5.22	5.06
K_2O	4.68	4.03	3.97	3.99	4.99
H_2O	0.60	0.43	1.37	0.63	0.56
P_2O_5	0.44	0.63	0.45	0.44	0.47

NM = Not Measured

1. Average monzonite, 46 samples, Nockolds, 1954.
2. Average larvikite, 15 samples, Nockolds, 1954.
3. Average nepheline monzonite, 7 samples, Nockolds, 1954.
4. Average larvikite, 3 samples, Killala Lake map unit 4c.
5. Average nepheline monzonite to monzonite, 7 samples, Killala Lake map units 5a, 5b.

The gabbroic rocks rim the syenite core and range from gabbro to olivine gabbro to troctolite. The rocks are medium grained, massive, and are crosscut by syenite and nepheline syenites. Disseminated sulphides associated with the gabbroic rocks are widespread in distribution. Coates (1970, p.6) reported a K–Ar isotopic age of 1185 ± 90 Ma on biotite from a gabbro sample collected from Sandspit Lake. Bell and Blenkinsop (1980) reported a Rb–Sr isotopic age of 1050 ± 35 Ma on syenitic rocks from the complex.

The Killala Lake Alkalic Rock Complex is located along a regional north–trending fracture which has served as emplacement control for a number of alkalic intrusions in the area.

EARLY PRECAMBRIAN (ARCHEAN)

METASEDIMENTS

Metasedimentary rocks (unit 1) envelop the Killala Lake Alkalic Rock Complex. The sedimentary rocks are now represented by biotite–quartz–plagioclase schists and hornblende–biotite–quartz–plagioclase schists. Compositional banding, up to several centimetres in width, perhaps represents bedding. Other structures that could be interpreted as former primary sedimentary features are lacking. The banding and schistosity are parallel and locally both are highly contorted. The metasediments are extensively intruded by both early and late (Early Precambrian) granitic rocks. The deformed banding and schistosity locally defines small fold structures in the metasediments.

The author interprets the metasediments as a former thick sequence of greywacke sandstones. They are grey to grey brown on weathered surface, grey, grey brown to grey black on fresh surface, and have a grain size of 1 mm or less. In thin section the rocks are fine grained, equigranular, allotriomorphic, granoblastic with curved to straight grain boundaries. The preferred orientation of the biotite grains defines the schistosity that characterizes the rock. Close to and at distances approaching 0.4 km from the contact with the complex, the metasediments display a transition from schist to gneissic hornfels. As the contact is approached the grey colour of the schists changes to brown and becomes dark brown close to the contact with the syenite. Here, the schistose nature of the rock has been destroyed and the rock breaks into angular blocks.

The author examined only a few thin sections from the wall rocks. Coates (1970) reported the mode of the metasediments as 30–35% quartz, 45–50% albite–oligoclase, and 15–20% biotite with trace amounts of garnet, muscovite, chlorite, and epidote. The author visually identified amphibole in a number of hand samples.

In the Killala Lake area, thin (up to several metres) units of hornblende–rich schists have been mapped as amphibolite. They may be either thin metavolcanic units or metamorphosed mafic dikes.

FELSIC INTRUSIVE ROCKS

Early Trondhjemitic Rocks

The early granitic rocks (unit 2a, 2c) are gneissic and appear to be pre–tectonic to syntectonic. These rocks cut the schists and are in turn cut by a later phase of more potassic granitic rocks. The early granitic rocks are visually estimated to contain 10–20% biotite, 50–60% plagioclase and are classified as trondjhemite

(map unit 2a). Rocks of this group are uncommon and occur only as isolated dikes, or lit–par–lit intrusions cutting the schists. Rock of this group were not examined in thin section.

Late Potassic Granitic Rocks

The most common granitic rocks are massive, equigranular, non–foliated granodiorite and quartz monzonite (unit 2b). These rocks occur as small masses and dikes cutting the schists and earlier granitic rocks and display a hypidiomorphic, equigranular texture characteristic of unmetamorphosed plutonic rocks. The larger bodies display a conformable nature with the schists, but the smaller bodies display more dike–like cross–cutting relationships.

One thin section was prepared from a late granitic rock from the south end of Sandspit Lake. This rock is a quartz monzonite composed of an estimated 30% quartz, 30% perthite, 30% plagioclase (An26), and 5% biotite. The rock is medium grained, equigranular, allotriomorphic, granoblastic with curved to embayed grain boundaries.

Early and late granitic rocks combined comprise an estimated 60% of the surface outcrop of the host rocks in immediate proximity to the Killala Lake intrusion.

LATE PRECAMBRIAN (PROTEROZOIC)

MAFIC DIKE ROCKS

Diabase

Diabase dikes (unit 3a) were not observed to cut the Killala Lake Alkalic Rock Complex, but they cut the surrounding Archean rocks. The dikes appear unmetamorphosed and are arbitrarily assigned to the Proterozoic pending future work on their relative age. The K–Ar isotopic age from the gabbroic border of the intrusion of 1185 $\pm$ 90 Ma (Coates 1970, p.6) establishes a minimum age for the dikes. The author suspects that the diabase dikes and gabbro rim of the complex could be contemporaneous.

Within the limits of the map area, diabase dikes are minor and occur only at isolated outcrops on Sandspit and Kagiano Lakes. Coates (1970, p.8–9) recognized two types of diabase in the region: (1) fine to coarse grained, massive, equigranular; and (2) porphyritic with plagioclase phenocrysts up to 3–4 cm in length. Mapping by the author in the Sandspit Lake area indicated the presence of small diabase dikes up to 60 m wide of a different appearance than described by Coates. These dikes may comprise a third class of diabase dike within the region. These dikes weather brown and are brown on fresh surfaces. The dikes contain greenish brown plagioclase phenocrysts that approach 12 mm in length, have a seriate distribution, and rarely exceed a visually estimated 5 volume percent of the rock. On the outcrop surface the rocks are fine grained, inequigranular, porphyritic and diabasic in texture. Biotite is present as small clots in the dikes and one dike contains three subrounded to subangular xenoliths of amphibolite (11 by 10 cm), syenite(?) (10 by 6 cm) and a fine–grained, aphanitic, felsic–looking rock (6 by 9 cm) with concentric rings up to 1 mm thick. Samples of the diabase dikes observed during mapping were not examined in thin section.

The spatial distribution of the outcrops of the largest of these dikes, located on the west shore of Sandspit Lake, suggests a north strike which would be paral-

lel to subparallel to the fracture system that likely controlled the emplacement of the Killala Lake Alkalic Rock Complex.

Lamprophyre

A number of lamprophyre dikes (unit 3b,c) cut the host rocks of the Killala Lake Alkalic Rock Complex. Their relationship to the complex is uncertain but presumably they are similar if not equivalent in age to lamprophyric dikes that cut the complex.

On a small outcrop at the north end of Killala Lake, an outcrop of metasediments cut by granitic pegmatite has been intruded by a lamprophyre dike. The dike is fine grained and black on weathered and fresh surfaces. Pits up to 4 mm in diameter on the weathered surface suggest the presence of olivine. The dike is approximately 2 m wide and trends at 055°. In thin section the dike contains a visually estimated 80% olivine altered to serpentine. The rest of the rock consists of roughly equal amounts of carbonate, chlorite, magnetite, actinolite and talc. The rock displays a well developed sieve texture characteristic of peridotite.

Several fine–grained mafic dikes are located along the shoreline of Kagiano Lake, northeast and southeast of the small island in the southern part of the lake. The dikes are 1–5 m wide, strike 035° and 345°, and dip steeply. The weathered and fresh surfaces are dark green and the surface deeply pitted. A thin section prepared from one of these dikes consists of a felty mass of actinolitized pyroxene and saussuritized plagioclase in roughly equal proportions. These dikes appear to be altered, fine–grained diabase.

On the shoreline of Kagiano Lake southeast of the island a small mafic dike 30 cm wide, trends 005° and dips vertically. The dike has a pitted, weathered surface and is dark green on both weathered and fresh surfaces. The dike contains small carbonate grains, up to 0.5 mm in diameter, that comprise an estimated 5% of the rock. The pitted weathered surface probably results from weathering out of the carbonate.

Coates (1970) reported analyses of 2 lamprophyre dikes (see Appendix A, Table A–2).

GABBROIC ROCKS

Gabbro

Gabbro forms the rim of the Killala Lake Alkalic Rock Complex. Olivine gabbro (unit 4a) is by far the most common variety of gabbro. Thin section examination has also disclosed the presence of gabbro (clinopyroxene + plagioclase) and troctolite (plagioclase + olivine).

Gabbro (unit 4c) appear to be an olivine–deficient, transitional phase of the olivine gabbro and cannot be distinguished from olivine gabbro in outcrop. Troctolite (unit 4b) can be distinguished in the field from olivine gabbro on the basis of colour index.

Bathe (1977, p.13), on the basis of thin section study, subdivided the gabbros of the rim into olivine gabbro, troctolite, noritic gabbro, and hypersthene gabbro. Hypersthene gabbro was considered by Bathe (1977, p.13) to be a chilled phase of the gabbro magma since it occurred only near the gabbro–country rock contact.

Olivine gabbro weathers dark rusty brown and commonly has developed a thick cover of grus over the outcrop making sampling difficult. On fresh surface

olivine gabbro is grey–brown to grey–black. Olivine, when visible in hand samples, is dark brown in colour. The gabbro is intruded extensively by nepheline syenite and syenite along its inner contact with the syenite core of the complex.

In thin section the olivine gabbros are medium grained, equigranular, allotriomorphic to hypidiomorphic with straight to curved grain boundaries. Olivine comprises an estimated 10–20% of the rock, pyroxene (augite) 10–40%, and plagioclase (An47–71) 44–70%. Magnetite occurs in quantities from 0–10%, apatite from trace to 1%, biotite from 0–5% and amphibole from trace to 2%. Chlorite and talc were noted. Coates (1970, p.11) reported trace amounts of spinel (hercynite) with the magnetite.

Olivine characteristically, but not always, has a deep reddish brown alteration along grain margins and curved fractures within the grains. The olivine grains are rounded to subangular in outline and are commonly associated with pyroxene. Coates (1970, p.11) reported that the olivine alteration is bowlingite. Kelyphytic rims consisting of symplectic intergrowths of light green amphibole and untwinned plagioclase are common along olivine–plagioclase grain boundaries. These symplectic intergrowths are oriented normal to the grain boundaries. Several thin sections also display a turbid, ill–defined reaction rim between the plagioclase and olivine. The mineral phases within this reaction rim could not be determined.

Pyroxene forms anhedral grains interstitial to the plagioclase. The pyroxene partially encloses olivine and poikilitically encloses apatite. The interstitial pyroxene, in places, partially engulfs the surrounding plagioclase, giving rise to a subophitic texture. Optically the pyroxene was identified as augite. Kelyphytic rims consisting of symplectic intergrowths of light green amphibole and untwinned plagioclase are common along pyroxene–plagioclase grain boundaries. These symplectic intergrowths form normal to the grain boundaries. Several thin sections also display turbid, ill–defined reaction rims between pyroxene and plagioclase. The minerals composing these rims could not be determined. The pyroxene invariably has a well developed schiller texture likely resulting from the exsolution of iron minerals along crystallographic planes in the pyroxene.

Plagioclase is invariably fresh and on occasion displays weakly bent, albite twin lamellae and fracturing which define a weak to moderately developed protoclastic texture. The author considers this protoclastic texture to be primary in origin. The possibility that this texture resulted from filter pressing of a crystallizing alkalic gabbro magma is worth considering.

Magnetite occurs as interstitial, anhedral, irregular, sometimes anastomizing, composite grains and also as individual, irregular, anhedral grains resulting from the alteration of principally olivine but also of pyroxene. The magnetite is likely the result of both primary crystallization and secondary alteration. Magnetite grains are commonly enveloped in a mantle of biotite with the (001) cleavage of biotite oriented normal to the grain boundaries. The presence of apatite, poikilitic in magnetite, is likely a relict feature inherited from the former pyroxene or olivine grains before alteration.

Biotite is a common product of alteration marginal to the interstitial magnetite grains and is also commonly associated with magnetite derived from the alteration of pyroxene and olivine. Biotite mantles amphibole that has resulted from alteration of pyroxene or olivine.

Amphibole (hornblende) is light green and brownish green in colour and comprises part of the symplectic intergrowths that make up the kelyphytic rims enclosing the olivine and pyroxene grains. In some cases the amphibole forms a

TABLE 3. MICROPROBE ANALYSES OF OLIVINE AND PYROXENE FROM OLIVINE GABBROS OF THE KILLALA LAKE ALKALIC ROCK COMPLEX (FROM WANLESS 1976).

	Pyroxene			Olivine	
Sample	KL-4-2	KL-4-12	Sample	KL-4-7	KL-4-10
$MgSiO_3$	37.8	37.9	Fayalite	48.1	55.1
$FeSiO_3$	16.2	14.6	Forsterite	51.0	43.7
$CaSiO_3$	45.9	47.5	Tephroite	1.0	1.2

simple mantle or corona to pyroxene and may in turn be at least partially mantled by biotite.

Trace amounts of sericite, chlorite and talc were each present in one thin section. Apatite occurs poikilitically as euhedral crystals principally in pyroxene, more rarely in olivine. Coates (1970, p.11) reported the presence of nepheline within the olivine gabbros. This observation could not be confirmed by the author and Wanless (1976) did not identify nepheline in the gabbros. Bathe (1977, p.13–20) did not report nepheline in the gabbro, but he did find hypersthene in samples collected close to the gabbro–wall rock contact.

Wanless (1976) reported several microprobe analyses of pyroxene and olivine from the olivine gabbros (reproduced in Table 3). The analyses confirm that the pyroxene is augite as was determined by the author.

The common presence of kelyphytic rims on olivine and pyroxene along grain boundaries with the plagioclase suggests disequilibrium between these primary mineral phases or late stage reaction with residual fluids. The formation of coronas presumably shielded and arrested the establishment of equilibrium between these primary mineral phases. The widespread occurrence of corona textures implies that the rims were a late stage autometamorphic or deuteric magmatic event and not the result of the later introduction of fluids. The author did not identify any undoubted adcumulus overgrowths on the early mineral phases. Symplectic rims account for a visually estimated 5% of some thin sections. The olivine gabbros are distinguished from normal gabbros on the basis of olivine content. The transition between olivine gabbro and gabbro is subtle, preventing subdivisions of the gabbros in the field. On the basis of estimates of modes, the normal gabbros are distinguished from the olivine gabbros by the presence of olivine in quantities of 10% or less. The mineralogy is otherwise identical to the olivine gabbros.

One section contains several grains of pyroxene with parallel extinction characteristic of the hypersthene.

Gradational from olivine gabbro and forming a distinctive but minor lithology, are a group of olivine–plagioclase rocks mapped as troctolite (map unit 4b). These rocks are blue–grey in colour and contain red–brown olivine. Rocks of this group contain an estimated 0–10% pyroxene (augite) and up to 30% olivine. The other minerals and their alteration products are identical to those for the olivine gabbro (map unit 4a).

Coates (1970, p.9–10) reported that the gabbro on the east side of Sandspit Lake is a pyroxene gabbro. The gabbro contains pyroxene–rich phases within it and also contains xenoliths of hornfelsed wall rocks. The author considers this pyroxene enrichment, in association with wall rock xenoliths, a local contact effect. The exposures are deeply weathered and thin sections were not prepared

from these outcrops. Coates (1970, p.12) reported that these pyroxene–rich rocks contain the essential minerals plagioclase (An50) and hypersthene.

A very fine–grained gabbro was locally observed. It could not be positively determined whether this rock represents a dike rock or a chilled possible contact phase of the gabbro. The author, however, prefers the latter interpretation. Tentative age relations suggests it is older than the olivine gabbro. Nepheline syenite and syenite intrude this gabbro as do the coarser–grained phases of the gabbro.

This rock unit weathers black and is black on fresh surfaces. In thin section the rock is fine grained, equigranular, massive, allotriomorphic, granoblastic, with straight to embayed grain boundaries. The rock is estimated to contain 15–50% pyroxene (augite), 50–60% plagioclase (An50–58), trace to 10% magnetite and 0–5% biotite. Biotite occurs as rims on the magnetite grains. Amphibole, after pyroxene, is pale green in color. Pyroxene forms subrounded, irregular grains and plagioclase forms an interlocking mosaic of anhedral grains. One thin section of fine–grained gabbro contains 10% or less orthopyroxene (hypersthene). One thin section contains more than 10% of each of clinopyroxene and orthopyroxene and was classified as norite.

Larvikite

Coates (1970) mapped a distinctive rock unit west of Papaver Lake as larvikite. The author observed similar rocks on the east rim of the complex. On the basis of a close spatial association with the gabbros and the local presence of segregations within the gabbro that are similar in appearance to the larvikite, the author originally mapped this unit as gabbroic anorthosite (Sage 1976). Considering the existence of protoclastic textures in the gabbro and the close spatial association of the larvikite with the gabbro, the possibility that the larvikite represents the crystallized equivalent of the decanted intercumulus liquid of a crystallizing filter–pressed gabbro is worth additional investigation. The scatter of chemical data of the gabbro on the AFM plot (see Figure 4) implies that the gabbros do not necessarily represent former liquid compositions, and conceivably could be the filter–pressed residuum of an olivine gabbro magma.

Chemical compositions of samples collected from this lithology are similar to those of monzonite from the core of the intrusion (see "Petrology", below). In the field, the larvikite of unit 4c and monzonite of unit 5 are distinctly different in texture, mineralogy and colour and can be easily mapped as separate phases. Even though both rock units are very similar in bulk composition, the central unit has been classified as monzonite and the outer units, spatially associated with the gabbro, have been classified as larvikite as suggested by Coates (1970). Sorenson (1974, p.567) defined larvikite as: "Augite monzonite or hypersolvus syenite, leucocratic, rhomb–shaped ternary feldspar, which is schillerizing. Nepheline or quartz may be present. Sometimes olivine bearing (= augite syenite or monzonite)." On the basis of the definition by Sorenson (1974), the rock can be classified as larvikite.

A more recent definition of larvikite (AGI 1987) is as follows:

"An alkalic *syenite*, grading to *monzonite*, composed of phenocrysts of two feldspars (esp. oligoclase and alkali feldspar), often intimately intergrown, which comprise up to 90% of the rock, with diopsidic augite and titanaugite as the chief mafic minerals, and accessory apatite (generally abundant), ilmenite, and titaniferous magnetite, and less commonly olivine, bronzite, lepidomelane, and quartz or feldspathoids (less than 10 percent by volume)."

TABLE 4. MICROPROBE ANALYSES OF PYROXENE FROM LARVIKITE OF THE KILLALA LAKE ALKALIC ROCK COMPLEX (FROM BATHE 1977).

	Pyroxene	
Sample No.	KR28-23-1	KR28-23-2
$MgSiO_3$	27.23	30.93
$FeSiO_3$	24.13	21.35
$CaSiO_3$	48.64	47.72

This definition is consistent with the use of the term larvikite to describe the feldspar–rich rock found at Papaver Lake. Future work on a larger sample suite and microprobe analysis may alter this useage.

In outcrop, larvikite forms high ridges and weathers brown to rusty brown; fresh surfaces are brown to grey–brown. The rocks are medium grained, locally coarse grained, and contain over 80% feldspar. The feldspar cleavages sometimes display a blue schiller effect in bright sunlight.

In thin section the rock is medium to coarse grained, equigranular, allotriomorphic with straight to curved grain boundaries. The rock is estimated to contain 30% clinopyroxene (augite), 5% olivine partially altered to a dark brown mineral, possibly iddingsite, and 5% magnetite. Trace to minor amounts of apatite and biotite are present. The olivine occurs as subrounded, subhedral grains, and the pyroxene as subangular, interstitial grains. The magnetite occurs as disseminated grains and as a minor alteration of olivine. Where present, biotite rims the magnetite. The pyroxene displays a weak schiller texture, similar to that found in the gabbros. Bathe (1977, p.74) presented microprobe analyses (reproduced in Table 4) of the pyroxene grains within the larvikite unit

The feldspars pose a problem in this rock unit. Coates (1970, p.17) reported the presence of orthoclase in anhedral crystals, some with vestigial albite twinning. The author has observed this vestigial twinning and determined a questionable anorthite content of An8 on two feldspar grains. The albite twinning appears as patchy, ghost–like relics within what otherwise appears as a homogeneous alkali feldspar grain. Under very high magnification, some homogeneous feldspars display a very fine, stringy perthite texture. Staining for potassium feldspar has failed to indicate the presence of significant potassium within the feldspar. This observation is in disagreement with the initial potassium content as determined by chemical analysis. Staining has, however, indicated the presence of potassium along grain boundaries and along fractures within the feldspar grains. Presumably this potassium is present as an incipient alteration of the feldspar which is predominantly untwinned and twinned plagioclase. Chemical analysis of these rocks (Appendix A) indicates a lower silica content, higher calcium content, higher iron content, and similar alkali contents to the syenite rocks. With respect to the gabbros, this rock in places contains more iron, more silica and has a much higher alkali content. The rock can be classified as a larvikite on the basis of similarity to chemical data compiled by Nockolds (1954) for larvikite rocks (*see* Table 2). The definition of larvikite by Sorenson (1974) and chemical data on larvikite compiled by Nockolds (1954) are consistent with the classification of this map unit as larvikite.

In an attempt to give a preliminary assessment of the feldspar problem, specimens of feldspar from the larvikite from one sample on the east flank and from

one sample on the west flank of the Killala Lake Alkalic Rock Complex, were hand picked and analyzed spectrographically for sodium and potassium. The feldspar from the east flank contains 3% sodium and 2% potassium metal and the feldspar from the west flank contains 4% sodium and 2% potassium metal. Calcium metal content was approximately 1% in both specimens. Chemical data indicate that staining of the feldspar did not give an accurate indication of the potassium metal content of the feldspar. Using immersion oils the feldspars were optically determined to be potassic, confirming Coates' (1970) identification of orthoclase. Alkali metal data however indicate that the orthoclase molecule likely forms less than half of the feldspar. The feldspar is therefore essentially a hypersolvus alkali feldspar which will require microprobe analysis and study to be accurately described. The feldspar may be close to orthoclase in composition.

NEPHELINE MONZONITE TO MONZONITE

Coates (1970, p.15–16) described a distinctive rock within the centre of the complex as olivine–nepheline syenite. On the basis of Coates' (1970) description the author classified this unit in the field as syenodiorite (Sage 1976). The unit forms an arcuate horseshoe–shaped mass open to the north and enclosing Kentron Lake.

Chemical data indicates a close similarity of this unit with the larvikite (see Appendix A). On the basis of both chemical and petrographic compositions, this map unit could be classified as either larvikite or monzonite. The petrography is in agreement with the definitions for larvikite given by Sorenson (1974, p.567) and AGI (1987, p.369) and the chemical composition is close to either larvikite or monzonite as given by Nockolds (1954). This definition is used by Sorenson (1974) synonymously with augite monzonite. The author uses the term monzonite to describe this unit to emphasize the different appearance of this unit from the larvikite found in the outer margins of the Killala Lake Alkalic Rock Complex.

Unit 5 has been separated from unit 4c on the basis of colour, feldspar content, texture and mineralogy. On the basis of limited chemical data monzonite may contain slightly more potassium than larvikite and slightly less silica. The differences are not great, and additional chemical analyses may close the small gap.

Chemically the monzonite is closer to Nockolds (1954) average composition for larvikite than that for monzonite (*see* Table 2). The rock has been further classified as nepheline monzonite since it contains a minor amount of nepheline.

In outcrop, the rock (unit 5a) weathers grey to pink, pale pink, grey, and light brown. On fresh surfaces the rock is pink–grey and sometimes has a pale green tint. Its fine–grained, porphyritic appearance is distinctive and easily recognized in the field. The rock contains Carlsbad–twinned, tabular, pink alkali feldspar phenocrysts up to 1.5 cm in length. In some outcrops the phenocrysts weather up to 2 mm in relief above the fine–grained matrix. The phenocrysts are randomly oriented in some outcrops but in others they are sub–parallel and define a weak but recognizable trachytoidal texture. The crystals rarely compose more than an estimated 15% of the rock, are seriate in distribution, and euhedral in outline. Since the monzonite is cut by dikes of coarse–grained syenite at several locations, the author considers the monzonite as pre–syenite in age and not post–syenite as proposed by Coates (1970, p.5). The author noted xenolithic fragments of monzonite in coarse–grained syenite at the northwest corner of Kentron Lake and a large, isolated block of monzonite occurs in coarse–grained syenite on the south shore of a small island in the southwest corner of Blank Lake.

In thin section the rock is fine to medium grained, inequigranular, porphyritic, seriate, allotriomorphic, with curved to straight grain boundaries. The feldspar phenocrysts are clear and display ragged edges with tiny inclusions of plagioclase. Staining of the phenocrysts failed to clearly indicate potassium feldspar. Optical data indicate that the feldspar is orthoclase.

The matrix is estimated to consist of trace to 10% olivine, 5–30% hornblende, trace to 25% pyroxene (augite), trace to 3% magnetite, trace to 10% nepheline and 50–65% plagioclase–perthite. On the basis of optical data, most plagioclase is oligoclase (maximum An30–34). The olivine forms irregular, bead–like grains with some minor dark brown alteration, possibly iddingsite, along grain margins and internal fractures. The pyroxene grains occur as irregular anhedral grains interstitial to the feldspar and are often mantled by dark brown to greenish brown amphibole. The amphibole is after pyroxene and pyroxene relicts are commonly present. The pyroxene sometimes has a poor to well developed schiller texture, reminiscent of that in the gabbros. The magnetite occurs as disseminated anhedral grains and may be rimmed with a trace of biotite. Apatite is common in trace amounts, and trace amounts of sericite are present in one thin section.

The feldspars pose a problem. A number of untwinned feldspar grains are present in any given thin section, however staining for potassium gives largely negative or poor results, indicating only minor potassium content. Potassium staining is often intense along grain boundaries and fractures within the grain. Under very high magnification, the grains without twinning commonly display a very fine, stringy perthite texture. A phenocryst was removed and examined spectroscopically for the alkali metals. The examination disclosed 2% sodium and 3% potassium metals. Calcium metal was 1%. Immersion oils indicated a similarity with orthoclase confirming Coates' (1970, p.16) optical identification. The spectrographic data suggest a hypersolvus feldspar with a dominant but by no means exclusive orthoclase molecule. On the basis of alkali metal content, the feldspar is likely anorthoclase. The presence of ragged edges to some of the phenocrysts and the inclusion of plagioclase in the periphery of the grain suggests some porphyroblastic overgrowth or late stage simultaneous crystallization of the two feldspars. The potassium staining along grain margins and fractures suggests potassium mobility, possibly metasomatism.

Coates (1970, p.16) reported the presence of nepheline while Wanless (1976) reported nepheline in only one thin section, however Bathe (1977, p.25–26) reported its presence as a minor phase throughout his sample suite. In thin section, the author observed nepheline to be present as interstitial, anhedral grains and as large, optically continuous grains which locally enclose feldspar grains. A very fine–grained alteration is present along fractures within the nepheline. This alteration is tentatively identified as sericite.

A fine–grained, birefringent mineral found in one thin section, thought by the author to be sericite, could as well be cancrinite after nepheline. In some exposures examined in the field, the author noted a white to grey white. pulverulent alteration of an unidentified mineral. The mineral is fine grained, interstitial to the other grains, and constitutes less than 1% of the outcrop. The author interprets this white to grey white altered mineral as possibly nepheline. On the basis of thin section and outcrop examination, the nepheline content of this unit is low, and erratic in distribution. Wanless (1976) presented microprobe analyses of olivine and non–porphyritic feldspars and Bathe (1977, p.74) presented microprobe analyses of pyroxene. The analyses (Table 5) indicate that olivine composition is fayalitic and feldpar is oligoclase.

TABLE 5. MICROPROBE ANALYSES OF MINERAL PHASES OF NEPHELINE MONZONITE TO MONZONITE. OLIVINE AND FELDSPAR FROM WANLESS (1976); PYROXENE FROM BATHE (1977).

		Olivine	
Sample No.	KL-14-1	KL-14-6	KL-14-9
Fayalite	82.0	80.9	84.3
Forsterite	14.4	14.9	11.7
Tephroite	3.6	4.1	4.1
		Feldspar	
Sample No.	KL-14-5	KL-14-8	
%Ab	83.0	72.6	
%An	15.3	25.3	
%Or	1.7	2.1	
		Pyroxene	
Sample No.	KR23-90-1	KR23-90-2	KR23-90-3
$MgSiO_3$	20.91	29.93	20.00
$FeSiO_3$	28.87	24.08	30.43
$CaSiO_3$	50.22	45.98	49.57

Non-porphyritic, medium-grained, equigranular monzonite (unit 5b) is identical to unit 5a except for the absence of phenocrysts and medium grain size.

Along the margins of the monzonite unit is a leucocratic sucrosic, fine-grained rock (unit 5c) that is distinctive, but does not form a mappable unit. In outcrop the width of this unit approaches 3-4 m. The rock is white or grey-white on the fresh and weathered surface. In thin section it is fine grained, equigranular, allotriomorphic-granoblastic, with curved to straight grain boundaries. An estimate of the mode is 1-5% magnetite, 1-5% greenish brown to dark green amphibole, trace to 10% nepheline and 80-95% plagioclase-perthite. Trace amounts of biotite and carbonate were noted. One thin section displays a sieve texture comprised of rounded blebs of plagioclase poikiloblastically enclosed in irregular, anhedral amphibole. Under high magnification, some feldspar grains have the appearance of string perthites. Mineralogy and texture of the rock are likely contact phenomena resulting from the emplacement of coarse-grained syenite into monzonite. Phases of the coarse-grained syenite commonly display a well developed trachytoidal texture in proximity to the contact.

SYENITIC ROCKS

Syenite rocks constitute an estimated 80-85% of the surface area of the Killala Lake Alkalic Rock Complex. The syenites vary from silica-undersaturated nepheline syenites of the periphery to silica-saturated syenites of the core. Within the south half of the complex the syenites are buff to pink-buff becoming red-pink, red to red-brown to the north. Within the nepheline-free syenites both mineralogic and colour changes are subtle and gradational into each other. As a consequence of these subtle differences, the gradational contact between buff and reddish-brown nepheline-free phases as shown on the map (Figure 3) is rather arbitrary and does not indicate significant compositional-textural differences.

The red-brown syenite appears gradational into the buff syenite. The contact between the nepheline syenite and nepheline-free, buff syenite can be estab-

lished with greater precision than than it can between the nepheline–free red and buff syenites. The subdivision of these two syenites is relatively easy due to the pitted weathered surface that is characteristic of the nepheline syenite.

Outer Nepheline Syenite

At the outer margin of the syenitic phases of the Killala Lake Alkalic Rock Complex, nepheline syenite (map unit 6h) lies in sharp contact with, and intrudes, the gabbros. The nepheline syenite in juxtaposition with the gabbros commonly displays a very well developed trachytoidal texture. Towards the core of the complex and away from the gabbro, the trachytoidal texture becomes less well developed. The overall nepheline content also decreases inwards and the nepheline syenite appears gradational into the buff nepheline–free syenite of the core.

The nepheline syenites are coarse grained and are easily recognisable by their deeply pitted, weathered surface resulting from the weathering out of interstitial nepheline. The feldspars are tabular or lath–like and where nepheline is abundant, the differential weathering has left the feldspars standing in relief forming a criss–crossed box–work on the outcrop surface in the less trachytoidal outcrops. The nepheline is pale pink to pale purple on the weathered outcrop surface, and is rarely altered to a red to orange–red hydronephelinite. The weathered surface of the nepheline has a frosted or turbid appearance. The rock is grey, buff, or pale pink on weathered surface and grey to buff on fresh surface. The mafic minerals, principally amphibole, are interstitial to the feldspars. Amphibole locally displays subophitic texture with respect to the feldspars, with single cleavage planes in the amphibole defining crystals up to 3 cm in diameter. Estimates on the outcrop surface indicate that the nepheline syenites contain 10–40% nepheline, 15–20% amphibole, and 40–75% buff, white or grey tabular feldspar. Locally, the texture coarsens to pegmatitic, and outcrops displaying this texture were classified as unit 6i. These local increases in grain size may represent local segregations of more volatile–rich magma and these are relatively rich in nepheline (estimated to be 40–50%).

On the basis of staining for potassium feldspar, estimates of relative importance of plagioclase versus potassium feldspar ratios suggests that modally the rocks are monzonite. However, rock chemistry is comparable to that of nepheline syenite (Nockolds 1954, Table 6) and the unstained feldspar is undoubtedly albitic plagioclase.

In thin section the nephline syenites are estimated to contain 10–25% nepheline, 0–25% dark brown–green to green–brown amphibole, 30–70% perthite, 0–65% plagioclase (An16? to 35), 0–5% pyroxene and 0–5% biotite. Trace amounts of sphene, magnetite, apatite, sericite, and carbonate are present. Most of the extinction (Michel Levy Method) angles for the plagioclase indicate albite to oligoclase compositions.

Nepheline is interstitial to the feldspars and displays incipient alteration along cracks. Staining for potassium has obliterated some of the textural features.

Also interstitial to the feldspar is a dark green to green brown amphibole that occasionally displays a subophitic texture to the feldspars. The extinction angles on the amphibole are similar to those of hornblende. The intense green–brown colour of the amphibole suggests that it is a high iron, and possibly, high sodium variety. Within the larger grains of amphibole, irregular relicts of pyroxene are present. The pyroxene requires microprobe analysis to determine its precise composition. Some amphibole grains display a slight colour change from a green–brown colour near the pyroxene relict to brown–green near the periphery of the

TABLE 6. AVERAGE NEPHELINE SYENITE FROM KILLALA LAKE ALKALIC ROCK COMPLEX COMPARED WITH AVERAGE NEPHELINE SYENITE FROM NOCKOLDS (1954).

	1.	2.
SiO_2	55.38	56.92
TiO_2	0.66	0.40
Al_2O_3	21.30	19.91
Fe_2O_3	2.42	2.12
FeO	2.00	3.18
MnO	0.19	NM
MgO	0.57	0.56
CaO	1.98	2.36
Na_2O	8.84	6.81
K_2O	5.34	6.30
H_2O	0.96	0.74
P_2O_5	0.19	0.18

NM = Not Measured
1. Nockolds, 1954, 80 samples.
2. Killala Lake, 15 samples.

grain, and thus there are likely subtle but distinctive compositional changes in the amphibole mantles on the pyroxene.

These pyroxene relicts give extinction angles that vary between that of diopside and that of augite. Coates (1970, p.18) described the pyroxene as aegirine–augite.

Biotite, where present, rims the amphibole and locally occurs within the amphibole.

The feldspars are complex. Two types of perthite are present: string perthite and patch perthite. The string perthite consists of hairline streaks of exsolved feldspar visible only at the highest magnification. The patch perthite contains patches with well developed albite twinning separated by a diffuse gradational boundary from patches of non–twinned feldspar which give a positive stain for potassium. The string perthite likely formed by the exsolution of a hypersolvus feldspar while the patch perthites likely formed as a late stage autometamorphic or deuteric replacement of plagioclase feldspar.

Plagioclase grains, where in obvious abundance, often display bent albite twin planes and minor fracturing. This texture is protoclastic and likely a primary feature resulting from the emplacement of the magma as a viscous crystal mush. Staining for potassium indicates that potassium is present along fractures and cleavage planes within the plagioclase grains implying late stage potassium addition to the feldspars.

The texture of the nepheline syenites collectively is coarse grained, massive, equigranular, allotriomorphic to hypidiomorphic with straight, curved, or embayed grain boundaries.

A minor lithology, originally mapped as aegirine syenite, was classified as hornblende syenite (unit 6m) after thin section examination. This rock is medium grained, grey to buff on weathered and fresh surface and characterized by long, acicular, euhedral, dark green crystals of amphibole. The crystals are strongly zoned from green–brown cores to green rims. Extinction angles may vary by several degrees from core to rim of the larger grains. Both plagioclase (An34?) and patch perthite are present and staining indicates an erratic distribution of potas-

sium. Nepheline occurs in minor amounts as interstitial grains. In thin section the mode is estimated as 35% sodic amphibole, 5% nepheline, and 65% plagioclase plus perthite. The texture is fine to medium grained, equigranular, massive, hypidiomorphic with curved to straight boundaries.

Another minor rock type is cancrinite syenite (unit 6n) found only on a small island in Kagiano Lake. In outcrop the rock varies from medium grained to pegmatitic and has a deeply pitted weathered surface. The rock weathers pink to grey and is grey to pale pink on fresh surfaces. Generally fine-grained, angular, xenoliths of mafic syenite up to 40 by 40 cm are present. Some xenoliths are nearly pure amphibole and Coates (1967, p.51) reported that some inclusions in the dike have well developed mafic reaction rims. Potassium feldspar crystals are abundant near some xenoliths. There is a crude banding to the outcrop due to variations in mafic-felsic mineral content and a weak suggestion of trachytoidal texture. The xenoliths, which may be autoliths resulting from the dismemberment of earlier solidified phases, show a weak tendency to be elongated parallel to the streaking and have a trachytoidal texture.

In thin section, cancrinite syenite is medium grained, equigranular, massive, allotriomorphic with curved to embayed grain boundaries. The mode was visually estimated as 45% orthoclase, 45% cancrinite, 10% amphibole, with trace amounts of garnet and calcite. The orthoclase displays well developed Carlsbad twins and is very fresh. The cancrinite forms large, continuous grains which poikilitically enclose some of the feldspars. The amphibole is zoned from dark brown cores to green rims. It has irregular grain boundaries and a worm-eaten appearance. On the basis of extinction angles, the amphiboles may have hornblende cores and riebeckite rims. Fluorite, nepheline, and biotite were tentatively identified in outcrop.

Nepheline syenite pegmatites are common in the vicinity of Blank Lake and on the small island on the south end of Kagiano Lake (unit 6p). The dike on Kagiano Lake is a coarse-grained phase of the cancrinite syenite described above.

At Blank Lake, the nepheline syenite pegmatites are very coarse grained and estimated to be composed of 40–50% pink to purple-pink interstitial nepheline, 5–15% black hornblende and 35–50% pink perthitic potassium feldspar (*see* Photo 1). The feldspars are tabular, have ragged sides and weather in relief with respect to the nepheline to form a criss-cross box-work pattern. The amphibole occurs in crystals up to 4 cm long, perthite in crystals up to 8 cm long, and nepheline in irregular, interstitial patches up to 6 cm in diameter. The pegmatites are of two types: those with sharp contacts, and those with more diffuse or gradational contacts. They appear to be largely late-stage segregations in shrinkage fractures within the cooling magma. They rarely exceed 15 cm in width or 10 m in length.

Within the dike described by Coates (1970, p.18) which forms an isthmus between two islands in Blank Lake and in some other pegmatites, fine-grained, leucocratic, sucrosic, aplitic phases are mixed with the coarse-grained phases.

Coates (1970, p.20) identified pyrochlore in these dikes and one grab sample assayed 0.35 Nb_2O_5. The author identified what he thought was pyrochlore in several dikes but their small size would indicate little economic value and additional sampling for pyrochlore was not deemed to be warranted. Several dikes contain euhedral, brown zircon crystals up to 1 cm in diameter. Where zircon is abundant, radioactivity is 2 to 3 times background. As with pyrochlore, the small size of the dikes eliminates any commercial value for the dikes other than as

specimens for the mineral collector. Thin sections and mineralogic studies were not attempted on the pegmatites. Coates (1970, p.19) also reported the presence of biotite, tourmaline, and magnetite within the dikes.

Inner Buff Syenite

Towards the interior of the Killala Lake Alkalic Rock Complex, the nepheline syenites of the periphery give way to the nepheline–free syenites of the core. On the basis of chemical analyses (Appendix A) this trend appears to largely reflect increasing silica content rather than any change in relative metal content. In the field, the change is noted by the general lack of pitting on the weathered surface. Some caution is necessary in using pitting to identify the presence or absence of nepheline, since the mafic minerals in some outcrops also weather down leaving a pitted appearance. Coates (1970, p.16) concluded that the nature of the contact, whether intrusive or gradational, is unknown. On the basis of field observations, the author believes that the contact is gradational. Also on the basis of field observations and spatial distribution of outcrops, some lithologic units are in sharp intrusive contact where normally intervening phases are absent. This appears to be the case for the nepheline syenite in the northeast and northwest corners of the complex where closely spaced outcrops suggest sharp contacts with red–brown syenite where the normally intervening buff syenite is absent.

The silica–saturated syenitic rocks of the southern half of the complex are buff, grey–white, white–grey to light brown on weathered and fresh surfaces (unit 6d). They are massive, homogeneous, coarse grained and equigranular. Within the area of Kentron and Blank Lakes the syenites display weak to well developed trachytoidal textures and mafic segregation banding. The syenites sometimes have perthite feldspar crystals up to 3–4 cm long. These crystals rarely comprise more than an estimated 5% of the outcrop, are seriate in distribution, and impart a porphyritic appearance to the outcrop (unit 6f). The mafic minerals have a subophitic arrangement with the feldspars and on the basis of cleavage surfaces, continuous grains of amphibole are up to 4 cm in diameter.

In thin section the general texture is medium to very coarse grained, equigranular, massive, allotriomorphic with straight to curved grain boundaries. It is difficult to accurately determine the mode of such coarse–grained rocks. The estimates are 0–1% olivine, 5–45% plagioclase (An28–39), 5–25% amphibole, 0–5% pyroxene, 0–10% biotite, 15–95% perthite and 0–10% nepheline. Minor apatite and magnetite and trace amounts of sericite, carbonate, zircon, sphene, chlorite and quartz are also present.

Olivine occurs as small grains poikilitically enclosed in pyroxene or amphibole after pyroxene, and has been deeply altered to a very dark brown mineral, possibly iddingsite. Optical determinations on the olivine alteration mineral were not diagnostic as to mineral type.

Small amounts of relict pyroxene occur as irregular grains within the cores of the larger grains of amphibole. The pyroxene is weakly pleochroic, has moderate relief, and is very pale green in colour. Extinction angles on the pyroxene vary from that of diopside to that of augite. The extinction angles obtained by the author are at variance with those of Coates (1970, p.14–15), who classified the pyroxene as aegirine–augite. The very pale green pleochroism of the pyroxene suggests that the aegirine molecule may be present in the pyroxene, but in subordinate amounts.

Perthitic feldspars are of both string and patch types with patch perthite by far the most dominant. The string perthites are generally recognisable only under

high magnification. The lack of potassium as indicated by the absence of visible staining on some string perthites implies that they may be peristerites (unmixed sodic plagioclase). The patch perthites consist of areas with well developed albite twinning separated by diffuse, irregular boundaries from areas of untwinned feldspar which give a positive stain for potassium. The string perthites may have formed by a subsolvus crystallization and the patch perthites may be a late autometamorphic or deuteuric feature. The perthite grains are irregular in outline and sometimes interstitial to the plagioclase. The larger perthite grains locally contain angular, broken fragments of plagioclase in a more or less random fashion. The plagioclase inclusions in some of the perthitic grains indicate that the perthite is later in order of crystallization.

Plagioclase commonly occurs in clusters of anhedral crystals forming a mosaic pattern, separated by anhedral, irregular perthite grains. The plagioclase commonly displays bent twin lamellae and minor fracturing characteristic of a protoclastic texture. This protoclastic texture of bent and broken plagioclase grains is interpreted by the author to be the result of the emplacement of the alkalic magma as a crystal mush.

Amphibole is dark brown to dark green with greener tints more common towards the margins of the grain. The maximum extinction angles fall on the low side of those typical of hornblende. The intense shades of brown and green suggest to the author that the amphibole is a high iron and possibly high sodium variety. The variation in colour tints across the grains imply that the amphibole crystals are zoned and that iron and sodium contents vary across the grain. Sodium–rich rims and iron–rich cores are expected. The larger amphibole grains contain relict pyroxene. The amphibole is clearly interstitial to the feldspar minerals.

Dark brown biotite sometimes rims the amphibole and at other times occurs as discrete booklets between the feldspars. This mineral, in part, occurs as a corona to the amphibole which in turn forms a kelyphytic rim on the pyroxene.

Euhedral apatite is poikilitically enclosed in the pyroxene and in the amphibole derived from the altered pyroxene. Magnetite occurs in very minor amounts principally as an alteration of olivine and sometimes pyroxene.

A minor phase of the buff syenite is a medium–grained, equigranular, massive variety that contains a much higher mafic content (unit 6k). On weathered surfaces the rock is brown to rusty brown, equigranular to slightly inequigranular, porphyritic, and is estimated to contain 35% mafics. Two thin sections of this rock contain an identical mineralogy but differing proportions. In thin section, pyroxene, dark brown to greenish brown amphibole, biotite, perthite, and plagioclase (An30–32) are the dominant mineral phases. Trace amounts of olivine and magnetite are present. The textural relations are similar to the coarse–grained phases.

Inner Red–Brown Syenite

Toward the northern portion of the complex the syenite changes from light buff and grey colours to pink, red, and then brown colours. Except for this colour change the rocks (unit 6j) have similar mineralogy and texture. Here, outcrops with large 3–4 cm perthitic phenocrysts may contain an estimated 10–15% of these larger feldspars. In places, some of the larger feldspar grains display a weak blue schiller when rotated in bright sunlight.

Further north, the red to red–brown syenite becomes increasingly more heterogeneous in texture and composition. Similar rocks also occur along the north-

east and northwest flanks where the syenites come in contact with schistose wall rocks without intervening gabbro. Grain size ranges from fine–grained aplitic to coarse–grained pegmatitic, and porphyritic textures are common. Wall rock xenoliths are locally abundant. Northwest of Barron Lake wall rock inclusions occur in such profusion near the base of a southeast–facing ridge that the rock could be described as an intrusion breccia or migmatite (Photo 2).

The deep red to brown colour of these syenites is likely the function of fine–grained, dusty hematite in the crystal lattice of the feldspars. The textural and compositional variations and xenolithic material indicates a relatively high level of exposure when compared with the more xenolithic–free and homogeneous buff syenites located in the southern portion of the complex. Due to their general textural inhomogeneity, these rocks were generally avoided for chemical analysis or extensive thin section examination. Along the east side of the intrusion, massive, red, medium– to coarse–grained, feldspar–rich dikes cut the schists in close proximity to the contact. These dikes are likely apophyses to the syenite intrusion and have been coded as unit 6l. The largest dike is approximately 3 m wide and nearly vertical in dip.

DIKE ROCKS

Dikes of unit 7 cut the rocks of the complex and are separated from dikes of unit 3 that are found in the wall rocks. In all probability, the lamprophyres of unit 3 may be equivalent to those of unit 7.

Feldspar Porphyry Dikes

A distinctive syenite porphyry dike rock occurs at Blank Lake (Photo 3). Most dikes of this composition (unit 7a) appear to be restricted to the area of Blank Lake, however one is located northwest of Kentron Lake. The dikes are grey, pink to pink–brown on weathered surfaces and grey to pink–grey on fresh surfaces. The dikes have a general north trend that varies 20–25° east or west of north, vertical dip and a maximum width of approximately 3 m. The dikes are composed of 20 to 30% feldspar phenocrysts in seriate distribution, reaching a maximum size of 2 cm. In addition to the phenocrysts, the dike rock is estimated to contain 30–40% hornblende and 30–40% feldspar in the groundmass. On outcrop, the dike is fine to coarse grained, inequigranular, porphyritic, hypidiomorphic.

Dikes of this rock, on the west side of an island in the northwest corner of Blank Lake, contain angular, xenolithic blocks of locally derived coarse–grained, trachytoidal syenite (Photo 4). Other dikes contain subangular to subrounded xenoliths of finer grained and more mafic syenites from an unknown source. The xenoliths are up to 1 m by 22 cm in dimension. The presence of two types of syenite xenoliths in a syenite porphyry dike cutting coarse–grained syenites implies three ages of syenite emplacement. The possibility that the mafic–syenite xenoliths are earlier chilled material from the dike itself cannot be discounted and only two ages of syenite emplacement can therefore be positively established. Along the margins of these mafic syenite xenoliths, a weak concentration of mafic minerals forms a rim 1–3 mm wide. The mafic syenite xenoliths generally weather slightly subdued with respect to the enclosing syenite dike rock.

In thin section, the rock is medium to coarse grained, inequigranular, porphyritic–seriate, massive, allotriomorphic to hypidiomorphic, with straight to curved grain boundaries. The mode is 15–20% dark brown to greenish brown amphibole, 5% biotite, 70% perthite and 5% plagioclase (An30?). Trace amounts of sericite and apatite are present.

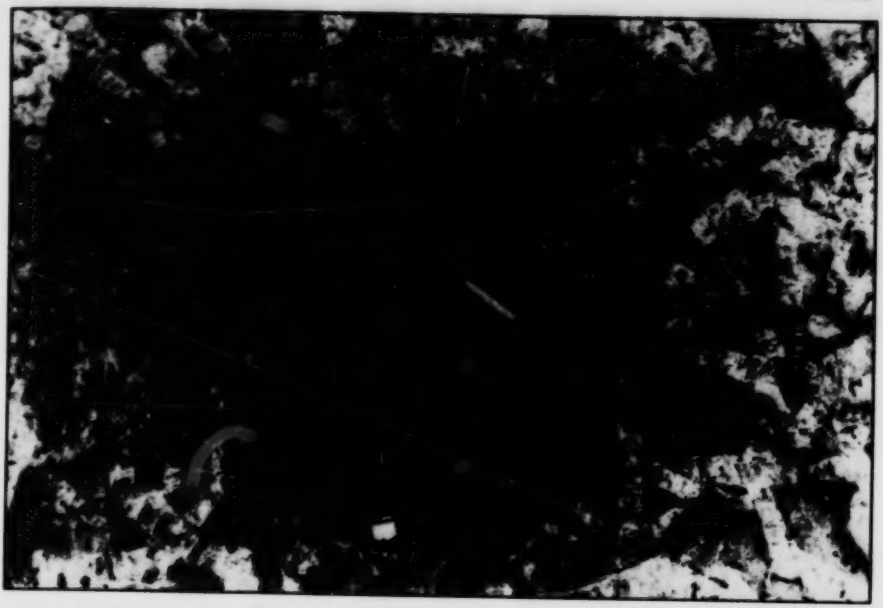


Photo 1. *Pitted weathered surface of nepheline syenite pegmatite on Blank Lake. Nepheline weathers subdued and tabular feldspar weathers high. Location P-4 on Figure 3.*

Photo 2. *Migmatized metasedimentary wall rocks. Exposure occurs well within the Killala Lake Alkalic Rock Complex and may represent former roof pendants and/or septums. Migmatite is generally found along the flanks of the arcuate ridges rather than on top. Ring fracturing and cauldron subsidence may account for their arcuate distribution. Location P-3 on Figure 3.*

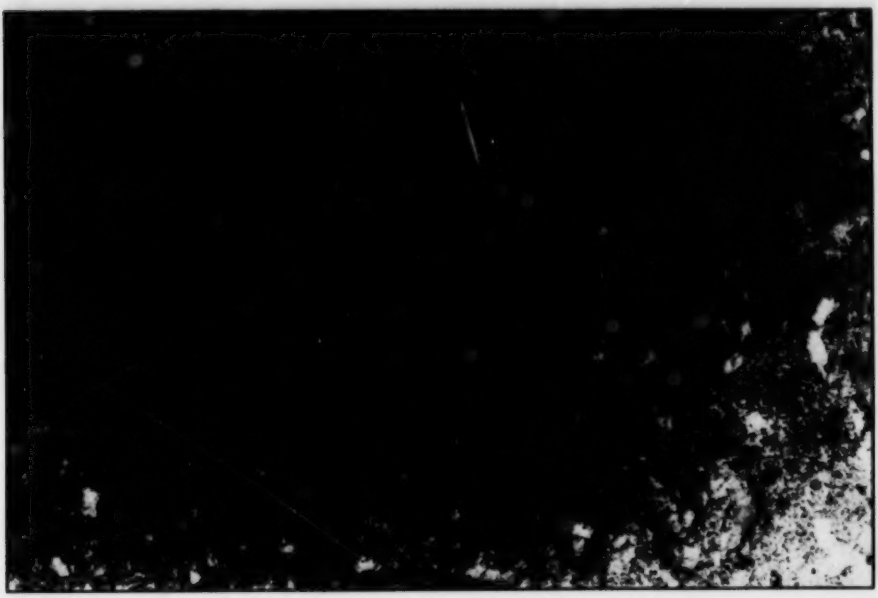


Photo 3. *Typical porphyritic texture of syenite porphyry dikes at Blank Lake. Location P-5 on Figure 3.*

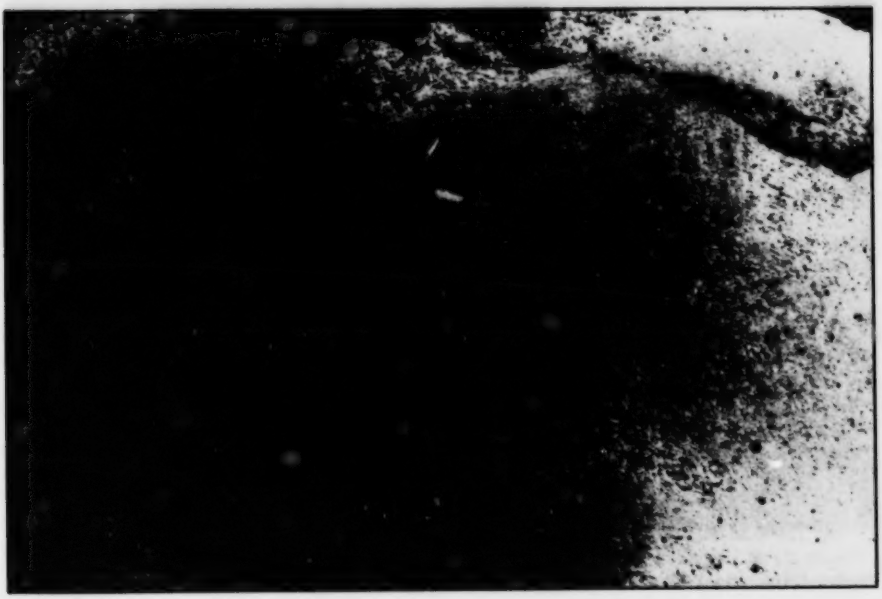


Photo 4. *Syenite porphyry dike with inclusions. Location P-6 on Figure 3.*

Coates (1970, p.15) considered the dikes to be equivalent to the arcuate monzonite body north of Blank Lake, but the author believes they are younger, for the following reasons: (1) coarse grained, almost pegmatitic syenite dikelets correlative to the enveloping coarse grained syenite were observed to cut the monzonite in several places along the contact south of Kentron Lake; and (2) blocks of the coarse-grained syenite occur as xenoliths within the dikes.

Lamprophyre

On the north shore of Kentron Lake, a lamprophyre dike (unit 7b) is 21 cm wide, has a strike of 105°, and dips 74° north. The dike occupies a fracture in the syenite and appears to be zoned from a very fine-grained margin to a slightly coarser-grained core. The dike weathers down with respect to the syenite and has a ribbed, weathered surface parallel to the strike of the dike. The weathered surface also has small pits up to several millimetres in diameter. The dike is black on both weathered and fresh surfaces.

In thin section, the rock is fine grained, inequigranular, porphyritic-seriate, hypidiomorphic. A visual estimate of the mode is 10% olivine phenocrysts, 5–10% pyroxene phenocrysts, 40% biotite (groundmass), 40–45% pyroxene (groundmass). Trace amounts of calcite, analcite?, and feldspar? are present.

The olivine forms irregular to angular, microporphyritic grains with dark brown alteration along grain boundaries and fractures. The microporphyritic phenocrysts are euhedral in cross-section and show a well developed concentric zoning. The matrix consists of a fine grained mosaic of biotite and pyroxene.

Intrusive Breccia

A distinctive breccia (unit 7c) occurs along the northeast shore of Kentron Lake. This breccia consists of angular to subangular fragments of coarse-grained syenite cemented with a black, xenocrystic matrix (Photo 5). No strike or dip for the brecciated zone could be determined. The breccia matrix weathers grey and subdued, leaving the clasts standing in relief. Pyroxene xenocrysts may be up to 1 cm in diameter and white, feldspar-rich clots up to several centimetres in diameter are locally present.

One of two thin sections examined displays a mortar type of cataclastic texture on one end and a diabasic or magmatic texture at the other end. The relationship suggests a mafic magma filling a fracture in brecciated syenite.

Plagioclase (An78) occurs in subrounded clots of anhedral grains that have reacted with the matrix. Olivine forms fresh subangular to subrounded grains with the suggestion of a very narrow reaction rim in contact with the matrix. A dark brown limonitic (?) alteration occurs along fractures in the olivine grains. Pyroxene (augite) forms xenocrystic grains with some euhedral outlines. Locally the pyroxene has a narrow reaction rim of biotite and/or amphibole. The sample with the diabasic matrix had a plagioclase grain with an anorthite content of approximately 60%. The variability of mineralogy between thin sections prevents any accurate estimate of the mode.

Aplite

A very minor dike phase was noted on Blank Lake and rarely on Kentron Lake. Fine-grained, equigranular, pink, aplitic dikes fill fractures in coarse-grained syenite on a number of outcrops. The dikes generally trend 20–25° east and west of north, are vertical dipping, and have a maximum width of 8 cm. The dikes are

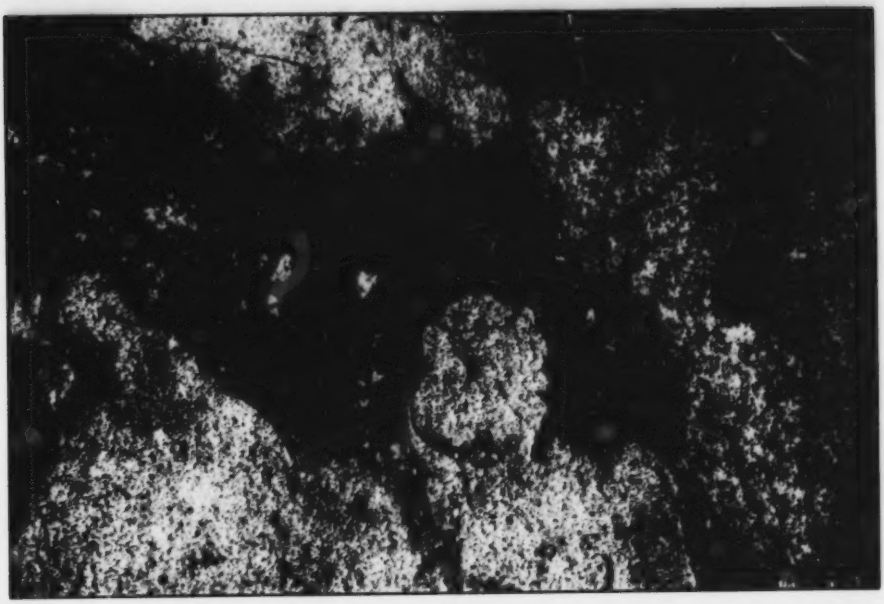


Photo 5. *Intrusive breccia cutting coarse grained syenites on the east shore of Kentron Lake. Note angular sharp contacts on fragments within the breccia. Location P-7 on Figure 3.*

thought to be late-stage fracture fillings. These dikes were not coded on the map or examined in thin section.

PETROLOGY

Appendix A contains petrographic descriptions of whole-rock samples (Table A-1), major element compositions (Table A-2), trace element compositions (Table A-3), normative compositions (Table A-4) calculated by the method of Irvine and Barager (1971), and statistical compositions of the lithologic units (Table A-5) calculated by the method of Nie *et al.* (1975). The rocks selected for analysis were chosen on the basis of freshness. Fresh samples were often difficult to obtain from rocks which characteristically weather deeply. Most of the fresher rocks came from the bases of cliffs and ridges. The weathered surface was removed as well as possible in the field and all samples were trimmed by diamond saw before submission for analysis. All weathered material was removed as well as many fractures displaying any form of alteration. The larger the grain size, the larger the sample submitted for analysis. As a result of the rigorous sample preparation, the chemical data in Appendix A should be representative of bulk rock composition. The syenites were in all probability intruded as crystal mushes, therefore the samples are from a suite of rocks in which cumulative or other processes may have operated, and caution is needed in extrapolating the chemical data to melt compositions.

Thin sections were prepared from all rocks submitted for chemical analysis. These sections were stained for potassium feldspar to aid in point counting. The staining has indicated complex feldspar relations, particularly perthite intergrowths, which combined with the coarse-grained nature of the rocks makes any modal estimate unreliable. Because of the complex feldspar relations, correlation

between rock groups should be on a chemical and normative basis rather than modally.

Alkalic magmas are related to continental rifting and low degrees of partial melting (Heinrich 1966; Bailey 1974; Gast 1968). The location of the Killala Lake Alkalic Rock Complex along a major regional fracture within the Canadian Shield is in keeping with an environment characteristic of alkalic rock intrusions. The Killala Lake complex is one of several alkalic rock – carbonatite intrusions that form a petrogenetic province north of Lake Superior.

Sorenson (1974, p.535–539) summarized the various theories concerning the origin of alkalic rocks, however a discussion of all of these proposals is beyond the scope of the present report. The order of emplacement from gabbro rim to silica–saturated core implies that crystal fractionation–differentiation of an alkalic basic magma produced the rocks found at Killala Lake. The parent alkalic magma was likely derived as a result of low degrees of partial melting in the mantle as suggested by Gast (1968). As pointed out by Wyllie and Huang (1976, p.103), the presence of H_2O in peridotite undergoing partial melting produces silica–saturated liquids and the presence of CO_2 produces silica–undersaturated liquids. Silica–undersaturated liquids would be required to generate the alkalic rocks found at the complex.

Isotopic ages of complexes in the area are: Prairie Lake Carbonatite Complex 1023 $\pm$ 74 Ma; Port Coldwell Alkalic Rock Complex 1070 $\pm$ 15 Ma; and Killala Lake Alkalic Rock Complex 1050 $\pm$ 35 Ma (Bell and Blenkinsop 1980), indicating the likelihood of a close petrogenetic relationship. The presence of the nearby carbonate–rich Prairie Lake complex implies that CO_2 was present in the upper mantle at the time of emplacement of the Killala Lake Alkalic Rock Complex and could have played an important role in alkalic rock magma genesis as suggested by the experimental work of Wyllie and Huang (1976).

Bathe (1977), using major element chemistry obtained by the author on the Killala Lake rock suite, plotted AFM diagrams which he compared with AFM diagrams of tholeiitic, alkaline and calc–alkaline trends. Bathe (1977) concluded that the Killala Lake alkalic rocks are all related and that the olivine gabbro was likely the parent magma. He also concluded that crystal fractionation was the process of differentiation but that cumulate processes were also a factor.

AFM plots by the author are shown in Figure 4. Figure 4a is a plot of the gabbro samples (unit 4a). The scatter of data combined with the protoclastic textures observed in this sample suite suggests that cumulate processes, or filter pressing, or both may have been operative and that the present chemical composition does not represent former silicate liquids simply derived by crystal fractionation processes. There is also the possibility that some alkali metasomatism at the time of nepheline syenite emplacement may have locally affected some of the samples which would modify the plotted position of the samples.

Plots of larvikite (Figure 4b) and monzonite to nepheline monzonite (Figure 4c) illustrate a close similarity between the two units even though in the field they can easily be distinguished on the basis of texture, grain size and colour.

Buff syenites of map units 6d and 6g are illustrated in Figure 4d. These diagrams display a rather tight clustering of data towards the alkali–iron leg of the AFM triangle. This plot may illustrate the mixture of a residual liquid and a cumulate phase of rather uniform composition. On the basis of petrographic and field observations, the syenites were likely emplaced as a crystal mush and thus they are in part cumulate, possibly a mixture of cumulate crystals and residual liquids.

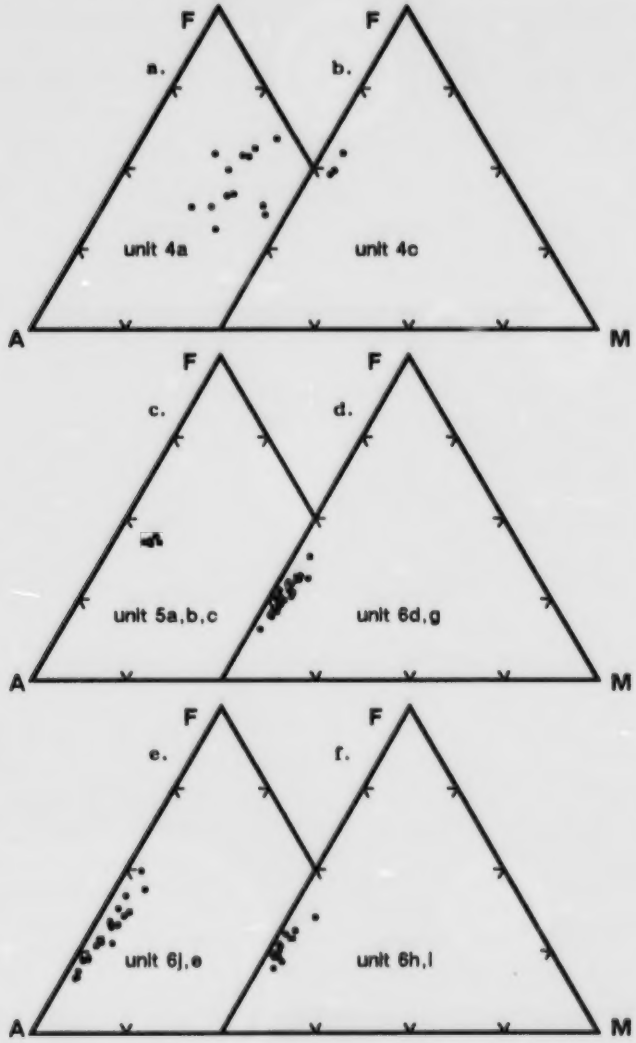


Figure 4. *AFM plots of samples from the Killala Lake Alkalic Rock Complex.* **a.** *Gabbro, unit 4a.* **b.** *Larvikite, unit 4c.* **c.** *Nepheline monzonite to monzonite.* **d.** *Coarse-grained, buff syenite, units 6d, g.* **e.** *Red-brown and brown syenite, unit 6j,e.* **f.** *Nepheline syenite, unit 6h,i. A = Na_2O; F = FeO (total); M = MgO.*

Red–brown and brown syenite (units 6j,e) are plotted in Figure 4e. This plot is similar to the plot for buff syenites and reflects the similarity in chemistry of these two rock units. The major difference observed in the field between units 6d,g and 6j,e is colour. The buff units of 6d and 6g appear to contain less ferric iron than the brown to red–brown rocks of units 6j and 6e. In the model presented here, the red coloured syenites are thought to represent higher levels of exposure in the Killala Lake syenite stock and that the colour is perhaps due to the presence of more oxidized (hematite) iron in the samples. The compositions of the buff and brown to red–brown syenites are generally equivalent or overlapping.

Nepheline syenites are plotted in Figure 4f. The plot is similar to Figures 4d and 4e. The major difference between the nepheline syenites and the other syenites is their generally lower silica content, which does not show on the AFM plot. The elements of interest in this plot appear to remain in the same relative proportions as the nepheline–free syenites of map units 6d, g, j, and e.

METAMORPHISM

The schistose and gneissic rocks enveloping the Killala Lake intrusion consist of biotite, quartz and plagioclase (An42) with thin amphibolitic horizons. The schists and gneisses were formed during regional metamorphism of the amphibolite facies of Turner (1968, p.307) or almandine amphibolite facies of Turner and Verhoogen (1960, p.544). The schists and gneisses have been extensively intruded by gneissic trondhjemite to granodiorite rocks. These granitic rocks may be either pretectonic or syntectonic and are sufficiently pervasive as to develop a mixed rock or migmatite terrain which displays, in varying degrees of development, ptygmatic, schollen, phlebitic, and stromatic type structures (Mehnert 1968, p.10–11). The crosscutting relations of some of the dikes suggests that the migmatite is an intrusive migmatite rather than anatectic; if anatectic, the anatectic melt is allochthonous and has moved from the site of generation. In addition, the metamorphic grade may have been too low to have formed the amount of anatectic granitic melt that is now represented by the granitic intrusions in some outcrops.

Intruded into the above rocks is a series of small, post–tectonic, more potassic bodies and pegmatite dikes of granodiorite to quartz monzonite composition.

Superimposed on the regional metamorphism is a contact metamorphic aureole represented by a hardening of the rock and development of a red to red–brown colour associated with the emplacement of the Killala Lake Alkalic Rock Complex. Locally along the margin of the intrusion, contact metamorphic effects are evident in the field at distances up to 300 m from the contact. Along the east, west, and north margins, the thermal–metasomatic aereole is narrower, generally varying from 30 to 90 m in width. The first evidence of the contact aureole is the colour change in the schists. On fresh surface, the unaltered schist is grey changing to various shades of brown nearer to the complex. Close to the contact, a faint brownish tinge to the schist on fresh surface becomes more and more intense and ultimately it becomes a deep rusty brown at the contact. The fissility of the schists disappears close to the contact and the rock has an intense rusty brown colour even on the weathered surface. At the contact the rock breaks into blocks with no trace of the fissility found in the more distant schists. Two hornfelsed samples were collected within 6–10 m of the gabbro – wall rock contact. Within the two thin sections of hornfels examined, biotite, quartz, plagioclase (An42–54), light green amphibole, clinopyroxene, orthopyroxene, and magnetite were observed. There may have been some depletion of silica and addition of iron close to the contact. The quartz content of the hornfelsed rock appears to be less than that normally found in the schists and the rusty brown weathering of the rocks suggests the addition or oxidation of iron. At the immediate contact of the Killala Lake Alkalic Complex with the enveloping schists is a narrow zone, less than 10 m wide, of pyroxene hornfels contact metamorphic facies (Turner 1968, p.225; Turner and Verhoogen 1960, p.520–521).

Within the intrusion itself deuteric or autometamorphic effects are pervasive. Kelyphitic rims on the primary minerals are common in the vast majority of thin sections. Such pervasive corona development suggests a disequilibrium between

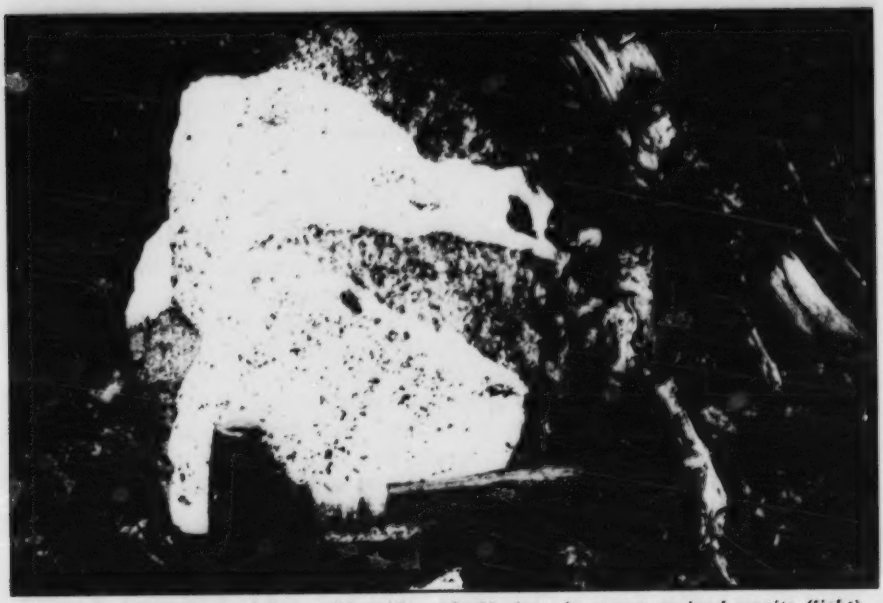


Photo 6. *Large block of float with gabbro (dark) clasts in coarse-grained syenite (light). Note angularity and lack of assimilation of gabbro by the syenite. This gabbro-syenite relationship is characteristic and implies that little reaction occurred between the syenite and the gabbro which it intruded. Location P-8 on Figure 3.*

the already crystallized minerals and the late stage intercumulus liquids within the crystallizing melt. The perthite feldspars are of two types: string perthite and patch perthite. The string perthite is by far the least common and likely results from hypersolvus exsolution of two feldspars. The patch perthite is interpreted as potassium replacement of the plagioclase feldspars. Staining of the thin sections has indicated that angular to subangular fragments of plagioclase are contained in random orientation in some irregular, interstitial to almost amoeboid potassium feldspar grains. This feature, combined with the observation that plagioclase twin lamellae may be mildly bent, implies that an original protoclastic texture, characteristic of an intruding crystal mush, was present and was partly obliterated by late-stage potassium metasomatism. Staining has also indicated that, since potassium is concentrated along grain boundaries, cleavage planes and fractures within the plagioclase feldspars, potassium was mobile. The plagioclase feldspars commonly display a weak but recognizable protoclastic texture in contrast to the unfractured potassium feldspar. While some of the potassium feldspar likely crystallized from late-stage melts, the textural relations indicate that some potassium was added during late-stage deuteric or autometamorphic addition. Gabbroic inclusions within the syenites are angular to subangular and show little evidence of the development of a reaction rim (Photo 6). These observations indicate that the syenites and associated magmatic fluids did not assimilate any quantities of gabbro at the present level of exposure. The field observations by the author are at variance to the conclusion of Coates (1970) that extensive assimilation had taken place. Bell and Blenkinsop (1980) reported a $^{87}Sr/^{86}Sr$ ratio of 0.7036 ± 0.0006 from Killala Lake Alkalic Rock Complex samples which they interpreted as indicating little influence or contamination by crustal rocks. A thin section of the syenite-gabbro contact indicates that the contact is sharp and the only evidence for reaction is the presence of a mafic selvage of light green amphibole of one grain width (less than 1 mm). In summation, on the basis of field and

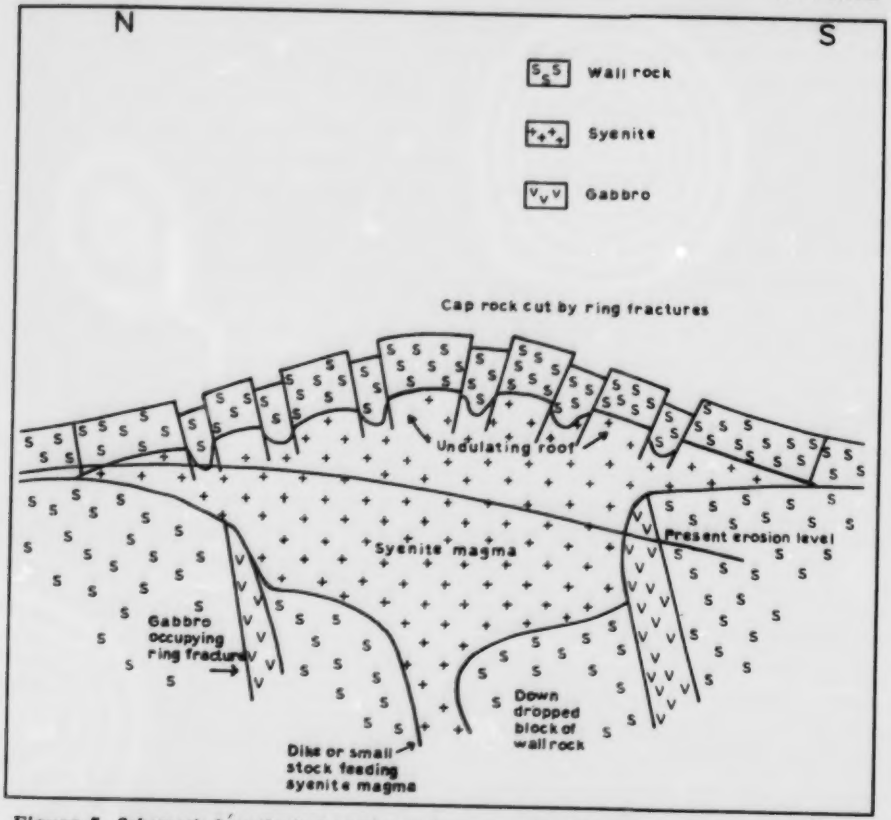


Figure 5. *Schematic hypothetical north–south cross-section through the Killala Lake Alkalic Rock Complex (not to scale).*

petrographic evidence, the syenitic rocks were emplaced as a viscous crystal mush which stewed in its own alkali–rich magmatic fluids as crystallization proceeded, resulting in late–stage autometamorphic or deuteric phenomena. Negligible assimilation of gabbro by syenite magma occurred.

STRUCTURAL GEOLOGY

The Killala Lake Alkalic Rock Complex sharply truncates the northeast trend of the surrounding Early Precambrian gneisses. The structural attitudes measured on the gneisses indicate that they have been little affected by the emplacement of the complex. This observation suggests that the complex is the mushroomed top of a dike or a small plug or that collapse along ring fractures of a circular or ovoid mass has occurred making room for the intruded mass (Figure 5). If the complex was a forcefully intruded cylindrical mass with vertical sides extending to depth, the disruption in structural attitudes of the enclosing gneisses would be anticipated to be greater than is observed.

Syenitic rocks of widely varying textures and grain sizes, sometimes xenolithic, were mapped in the northern portion of the complex. This textural variability also occurs along the flanks and/or tops of ridges of outcrop, or in the low areas between the ridges and is considered by the author to be characteristic of those rocks found in areas of contact between the complex and enclosing wall rocks. The ridges of outcrop are also curvilinear and reflect the general shape of

the complex. This observation suggests that the upper surface of the complex was undulatory or perhaps represented a series of parallel concentric ring fractures resulting from caldera–style collapse of the overlying roof rocks during emplacement. The observation of these high level structural and petrographic features in the northern portion of the complex and their absence in the southern portion, suggests a deeper level of erosion and exposure for the southern portions. If this interpretation is correct, the present level of exposure represents an oblique cross–section through the complex. The horseshoe–shaped outcrop pattern open to the north of the various lithologies would also support such an interpretation.

Coates (1970, p.23) suggested that the syenites on the northern flank of the complex may be a sheet–like mass (petal–like laccolith) which overlies gabbroic rocks similar to those found along the southern margin of the complex. This interpretation was based on the observation that a circular aeromagnetic pattern on the northern side of the complex does not follow the mapped outline of the intrusion nor can it be explained by the rocks presently exposed at surface (Figure 5, ODM–GSC 1963a,b). On the basis of both field and aeromagnetic data, the author concurs with this interpretation of Coates (1970, p.23).

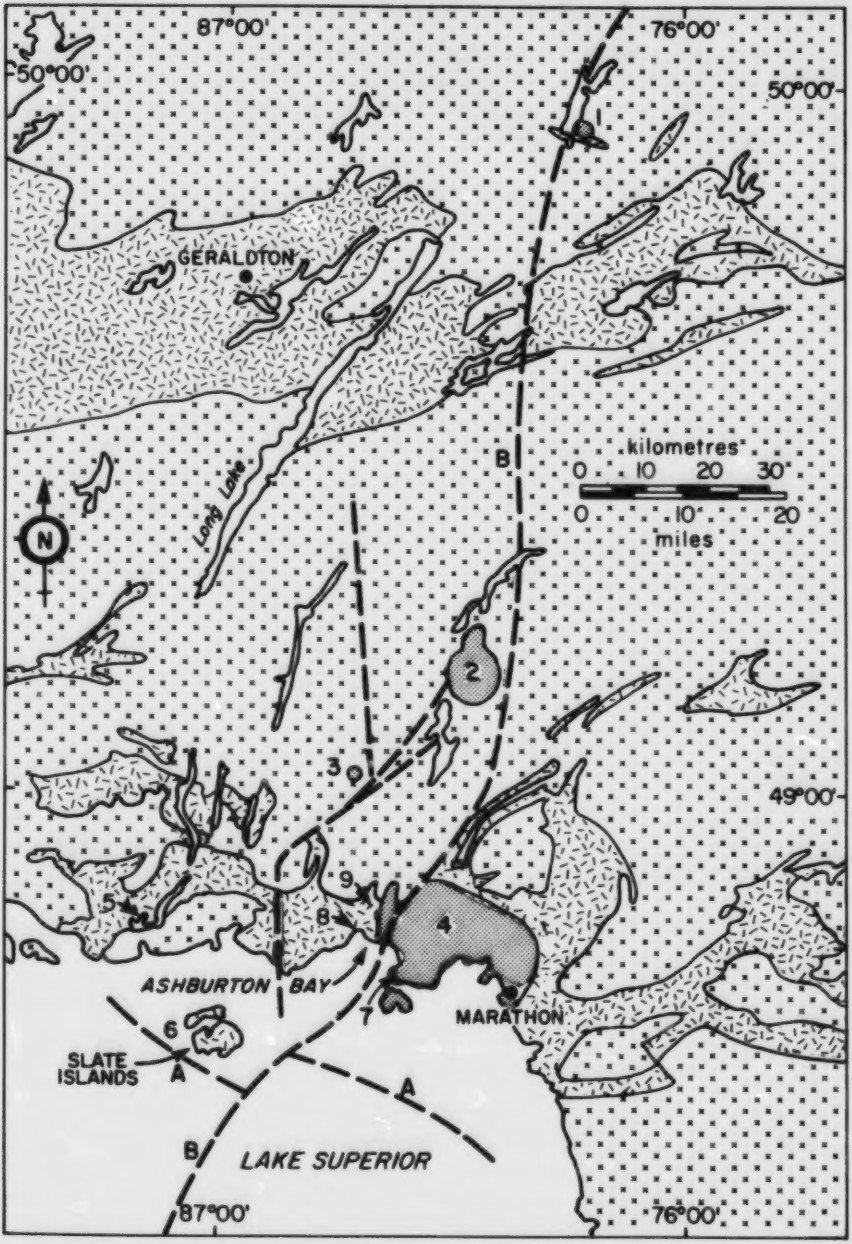
In the southwest corner of the complex, syenitic rocks occur on the crest of a prominent ridge while gabbro is present on both flanks. This observation also supports Coates' (1970, p.23) suggestion that the syenites may in part locally overlie gabbroic rocks along the periphery of the intrusion.

REGIONAL STRUCTURAL SETTING

Coates (1967, p.89–95) discussed the possibility that the Killala Lake Alkalic Rock Complex is associated with continental rifting. The association of alkalic magmatism and continental rifting is well documented (Heinrich 1966; Bailey 1974). Alkalic magmatism is diagnostic of low degrees of partial melting in the mantle or lower crust (Gast 1968). On the basis of work completed earlier by the author on the Slate Islands (Sage 1988), the Killala Lake Alkalic Rock Complex lies on an extension of the Big Bay – Ashburton Bay Fault that crosses the Lake Superior basin in a northern direction (Hinze *et al.* 1966). At a point along this fault Smith *et al.* (1966) have determined on the basis of seismic data that the crust approaches a thickness of 55 km. The geophysically inferred fault of Hinze *et al.* (1966) was extended north of Lake Superior by Sage (1976) on the basis of published geological maps and linear trends on ERTS imagery. North of the Killala Lake Alkalic Rock Complex, and along the same fracture, the Chipman Lake fenites are found, and south of Killala Lake, the Port Coldwell Alkalic Complex is located along this same fracture. Coates (1970) mapped this fault along the east side of the Killala Lake complex and referred to it as the Boomerang Lake fault. The Killala Lake Alkalic Rock Complex thus lies in a structural environment characteristic of alkalic rock complexes (Figure 6).

Using lineament analysis, aeromagnetic and gravity data, Klasner *et al.* (1982) have extended the fractures hosting the Port Coldwell and Killala Lake Alkalic Rock Complexes across and south of Lake Superior. The Big Bay – Ashburton Bay Fault (Sage 1978) was referred to as the Thiel Fault by Klasner *et al.* (1982) and this broad zone of north to northeast striking faults was referred to collectively as the Trans–Superior Tectonic Zone. The Trans–Superior Tectonic Zone bisects the Lake Superior basin or Midcontinent rift system and roughly subparallels the Kapuskasing Structural Zone to the east which also hosts many alkalic rock – carbonatite complexes.

South of Lake Superior, post–Ordovician kimberlite intrusions may be associated with this regional structure (Cannon and Mudrey 1981).



1. *Chipman Lake carbonatite dikes and fenites*
2. *Killala Lake Alkalic Rock Complex*
3. *Prairie Lake Carbonatite Complex*
4. *Port Coldwell Alkalic Rock Complex*
5. *Gold Range diatreme*
6. *Slate Island diatremes*
7. *Neys diatreme*
8. *McKellar Creek diatreme*
9. *Dead Horse Creek diatreme*

A. Michipocoten Island fault
B. Big Bay – Ashburton Bay fault and its extrapolated northern extension.

Granitic rocks

Supracrustal rocks

Fault zones

Figure 6. *Sketch map showing relationship of faulting and alkalic rock magmatism north of Lake Superior.*

Immediately east of the Port Coldwell Alkalic Rock Complex, Platt *et al.* (1983) have identified ultrabasic lamprophyres of 1.65 Ga age using Rb–Sr isotopes and on the Slate Islands Sage (1988) has identified a lamprophyre of approximately 300 Ma using K–Ar isotopic techniques. Alkalic rock – carbonatite magmatism has occurred at many widely separated periods of time along the Trans–Superior Tectonic Zone, but the main event represented by the Prairie Lake Carbonatite Complex and Killala Lake and Port Coldwell Alkalic Rock Complexes is approximately 1100 Ma.

A positive linear aeromagnetic anomaly of approximately 200 gammas absolute total field intensity strikes southwest from the Killala Lake Alkalic Rock Complex to the Prairie Lake Carbonatite Complex (ODM–GSC 1963b). The Killala Lake complex is similar in age to the Prairie Lake complex and undoubtedly they are petrogenetically related. This magnetic trend is parallel to linear trends on ERTS imagery of the area and implies that the Killala Lake complex occurs at the intersection of a north–trending regional fracture from the Lake Superior basin (Big Bay – Ashburton Bay Fault) and a more local northeast–trending fracture.

Studies by Lilley (1964, p.70) of aeromagnetic data covering the Port Coldwell Alkalic Complex, which is similar in age to the Killala Lake complex and located along the same fracture, have indicated that the Port Coldwell complex is mushroom shaped in cross–section (cone 4.0 km deep). The relatively large surface area of the Port Coldwell complex (approximately 450 km^2) decreases to a small stem less than 0.8 km in diameter at a very shallow depth. This stem may plunge steeply southwest beneath Lake Superior and along the general trend of the Big Bay – Ashburton Bay Fault (geophysically inferred by Hinze *et al.* 1966) in keeping with the angle of emergence of seismic waves measured by Mereu (1965). The change in level of exposure from north to south across the Killala complex and the apparent lack of disruption in regional structural trends suggests such a model may also apply to the Killala Lake Alkalic Rock Complex. Coates (1970, p.23) has suggested a conical or funnel shape for the mass.

Using gravity data Currie (1980) and Mitchell *et al.* (1983) have interpreted the positive gravity anomaly above the Port Coldwell Alkalic Rock Complex as indicating that mafic rocks are much more abundant at depth than are exposed at surface. The roots of the Port Coldwell Alkalic Rock Complex extend to the lower crust or upper mantle (Currie 1980; Mitchell *et al.* 1983). A gravity study of the similar Killala Lake Alkalic Rock Complex may result in similar interpretations.

Exposed contacts of the complex with its wall rocks are rare, but where observed are vertical to subvertical. This attitude is consistent with either ring fracturing and/or up–doming. It is likely that ring fracturing and up–doming took place at the junction of two faults, and were followed by caldera–type collapse of the overlying rocks during emplacement.

Stoping of blocks may have taken place but this is not likely to have been the dominant process of emplacement since large blocks of wall rocks do not exist within rocks of the complex.

SMALL–SCALE STRUCTURES

Mineralogic banding occurs in the gabbroic rocks and has been described by Coates (1967, 1970). The deeply weathered nature of the gabbro and generally small size of the gabbro outcrops have prevented detailed observations of this feature in the field. Its presence is indicated in some random core samples col-

lected from the former camp sites of Killala Lake Mines Limited. Coates (1967, p.66) mentioned having difficulty in finding mineralogic layering in the field. Coates (1967, p.66) reported mineral layering on the order of 15 cm to 1 m in diamond drill core at the Sandspit Lake location of Killala Lake Mines Limited. At this locality black magnetite–rich layers grade gradually into dark grey layers composed largely of plagioclase with minor pyroxene (Coates 1967, p.66). The dark portion of an individual layer is usually thinner than the lighter part and the alignment of plagioclase feldspar crystals defines a trachytoidal structure (Coates 1967). Coates (1967) reported that olivine occupies spaces interstitial to the feldspars and that pyrrhotite layers up to 2 cm thick occur within the leucocratic portions of the layers. Usually only one sulphide band was present in the leucocratic portion of any given band (Coates 1967). The pyrrhotite is interstitial to the other minerals (Coates 1967).

Trachytoidal textures, defined by a preferred orientation of lath–like feldspars, are only locally apparent in the nepheline monzonite to monzonite (unit 5). The trachytoidal texture is rarely strongly developed and commonly is unrecognizable in outcrop.

The nepheline syenites along the periphery of the complex have an excellent trachytoidal texture (Photo 7) developed in close proximity to the gabbro–syenite contact. The trachytoidal texture locally exhibits such strong orientations that a cleavage is developed in the rock parallel to the (010) cleavage in the feldspar. The trachytoidal textures within the nepheline syenites dip inward towards the interior of the intrusion at angles of approximately 50–60°.

Near the core of the complex, trachytoidal textures and mafic segregation banding are common in the Blank Lake area (Figures 7 and 8). On Kentron Lake mafic segregation bands (Figure 9) are common and very well developed

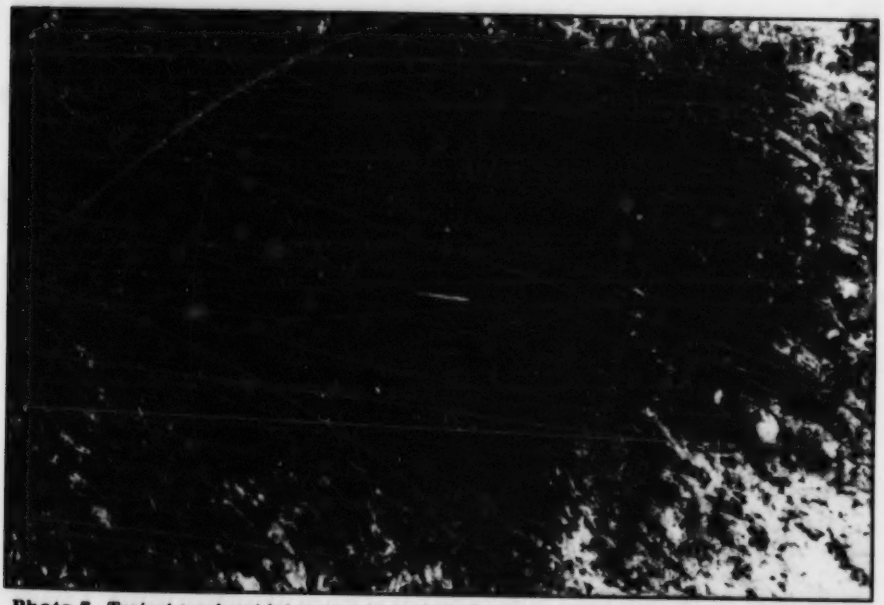


Photo 7. ***Typical trachytoidal texture in nepheline syenites found along the rim of the Killala Lake Alkalic Rock Complex. Black mineral is amphibole, tabular mineral is potassium feldspar and interstitial nepheline is not visible. Location P-9 on Figure 3.***

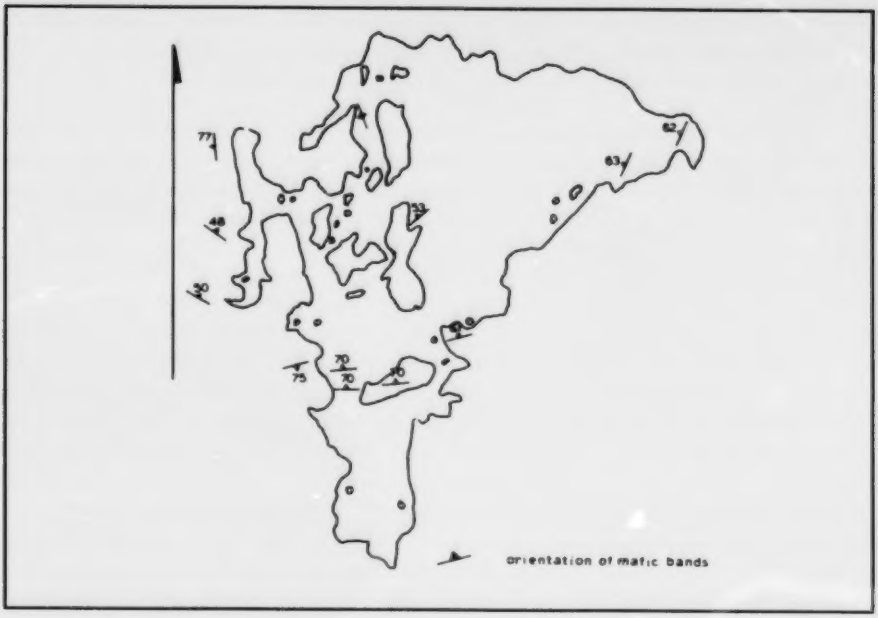


Figure 7. *Mafic segregation banding trends in Blank Lake syenites.*

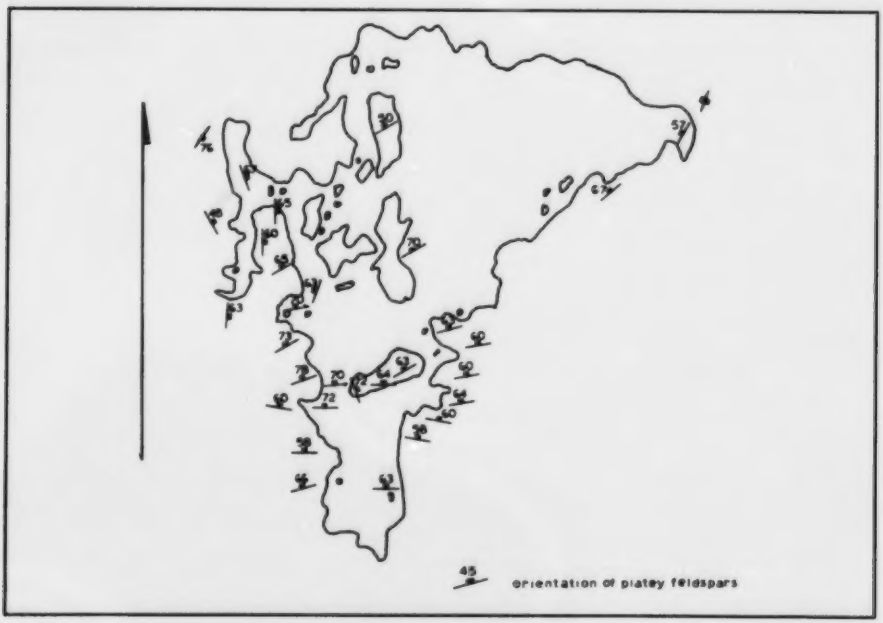


Figure 8. *Trachytoidal textures in Blank Lake syenites.*

Figure 9. *Mafic segregation banding trends in Kentron Lake syenites. Arrows on north side of lake indicate direction of younging based on crosscutting relations of bands. Trachytoidal textures are parallel to mafic banding.*

on the northwest shore. The trachytoidal textures are best developed in those syenites with highest mafic content.

On Kentron Lake the mafic segregation bands vary from 3 to 5 cm in width and have a spacing on the order of 5–15 cm. The individual bands have diffuse contacts with the surrounding leucocratic syenite. The bands contain a higher mafic content than the usual syenite and as a result weather down giving a ribbed appearance to the outcrop. The bands occur in arcuate sets giving the impression of cross–bedding (Photos 8 and 9). Individual bands may fade out along strike. Trachytoidal textures are more strongly developed within these bands than within the surrounding syenite.

The mafic minerals which give rise to the banding have a subpoikilitic to poikilitic relationship with the oikocrystic feldspar and clearly indicate that the bands represent concentrations of mafic intercumulus liquid which contained potassium feldspar crystals. The presence of protoclastic textures in the early formed plagioclase within the syenites implies emplacement of the magma as a crystal mush. On the basis of field and petrographic observations, the banding results from concentration of the intercumulus liquid during intrusion. The higher degree of preferred orientation of the feldspars within the mafic bands than outside indicates that the greatest amount of movement or adjustment during emplacement took place within the bands of intercumulus liquid. These bands are least capable of supporting shear stress. The apparent pattern of cross–bedding represents upwellings of crystal mush in a highly viscous state. The interference pattern resulting from the upsurges gives the arcuate pattern of the bands which are then truncated by a younger set of arcuate bands by a later upsurge. One outcrop displays four sets of arcuate bands with truncation always being in the same direction. If the direction of truncation indicates the direction of continuing younger magma then the direction of younging should point to the area of magma

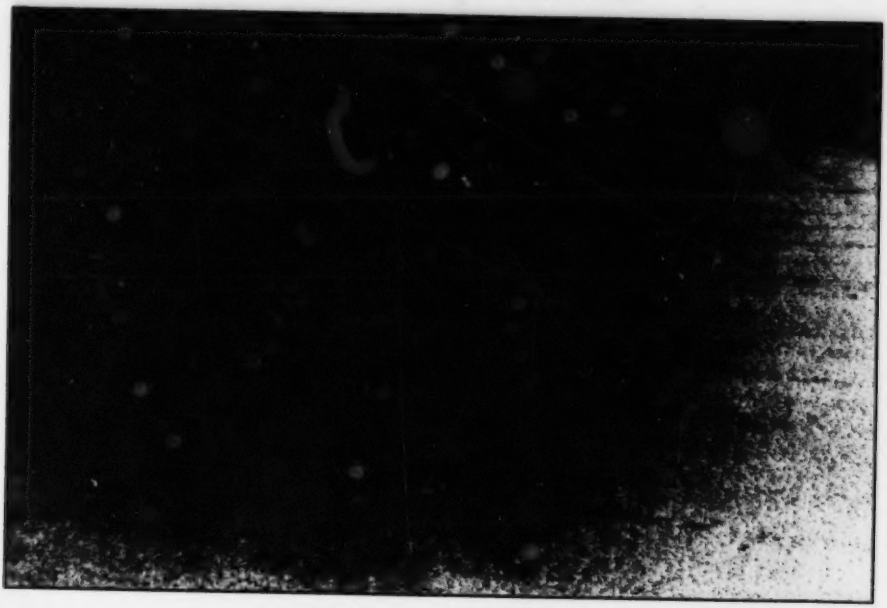


Photo 8. *Mafic segregation banding in coarse grained syenite on Kentron Lake. Note truncation of one set of bands by a second set. Location P-10 on Figure 3.*

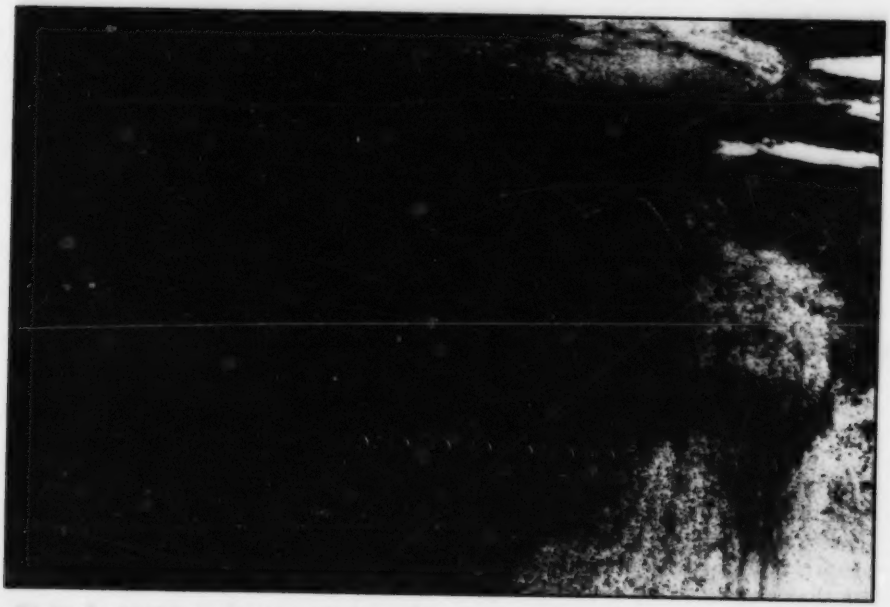


Photo 9. *Arcuate mafic segregation banding in coarse-grained syenite on Kentron Lake. Note the lack of sharp contacts of the mafic segregation bands with the coarse-grained syenite. Location P-11 on Figure 3.*

upsurge. Using this feature as a means of identifying the direction of magma upsurging, the site would be north to northeast of Kentron Lake. Considering the relatively high level of exposure postulated for this portion of the intrusion and a mushroom shape in vertical extent, movement or adjustment between bands would result largely from spreading or lateral movement of the crystal mush at this structural level (*see* Figure 5).

Mafic segregation banding on Blank Lake is much more indistinct than on Kentron Lake. On Blank Lake the banding occurs largely as one or two indistinct but recognizable streaks in any given outcrop. Trachytoidal feldspars and mafic segregation banding are always parallel.

Mapping by Coates (1970) indicated a more or less random pattern to the mafic banding within the complex. There are three types of mafic banding in the complex: (1) mafic segregation banding; (2) pegmatitic segregations; and (3) pegmatitic segregations along cooling fractures or joints.

Only the mafic segregation banding is considered by the author to have formed as a function of emplacement. The other two forms of mafic banding represent the collection of late stage fluids in a largely solid body. The somewhat random pattern of banding attitudes recorded by Coates (1970) may result from the fact that he did not distinguish the various types. Plotting of mafic segregation band attitudes recorded by the author indicates a very systematic pattern (*see* Figures 7 and 9). The pattern suggests that in addition to recognizing small individual magma pulses on an individual outcrop by truncation of one set of bands by another, the band attitudes occur in distinct groupings, implying that larger magma upwellings occurred (*see* Figure 9).

Experimental studies with viscous glucose by Nickel *et al.* (1967, p.440) indicate that crystals and shear planes associated with intrusion orient themselves normal to the direction of maximum compression. These experiments appear consistent with the model outlined above to explain the field observations by the author at Kentron Lake and Blank Lake.

Considering that the present plan view of the complex represents an oblique cross–section of the intrusion, a change of primary igneous structures is apparent from south to north. In the south, the syenites are dominantly structureless; further north, trachytoidal textures become recognizable and weak, ill–defined, mafic banding is present at Blank Lake in the south central part of the complex. North of Blank Lake and higher stratigraphically, mafic segregation banding becomes increasingly better developed reaching its best development on the north side of Kentron Lake. The well developed mafic segregation banding and trachytoidal textures disappear at stratigraphically higher positions in the red, inhomogeneous syenites. Experimental studies by Nickel *et al.* (1967, p.447) using rigid bodies in glucose, support this variation in internal structures with level of exposure.

FAULTS

Coates (1970, p.22; 1967, p.72) defined four regional fault sets for the area, trending (1) north to 015, (2) northwest, (3) northeast, and (4) parallel to the strike of the country rocks. The north set which is subparallel to parallel with the north–trending fracture that controlled the emplacement of the Killala Lake Alkalic Rock Complex, Port Coldwell Alkalic Rock Complex, and Chipman area fenites, is also the trend of diabase and mafic dike intrusion in the area (Coates 1970, p.22).

Coates (1970, 1967) mapped as faults a number of linear structures within the Killala Lake Complex. The author could not confirm offset for most of these linear structures and has mapped them as linears only. An abrupt change in lithology of the gabbro was observed along the southwest contact between gabbro and wall rock east of Sandspit Lake and within the syenite rocks along the north–trending appendage of Papaver Lake. The abrupt lithologic changes have been attributed by the author to faulting (Sage 1976). Both interpreted faults are left–lateral with displacement of approximately 240 m on the fault along the southwest contact and 300 m on the fault at the south end of Papaver Lake.

In the southeast corner of Kentron Lake an apparent left–lateral offset of the monzonite of approximately 120 m suggests faulting at this location.

RECOMMENDATIONS FOR FUTURE STUDY

Noteable features of the complex include the pervasive development of kelyphytic rims and replacement and symplectic textures on the primary mineral phases throughout the complex. The mineralogic and chemical changes that have taken place are likely critical to any precise petrogenetic modelling of the intrusion. The kelyphytic rims are likely to be chemically and mineralogically zoned, but microprobe analysis will be required to determine the nature of any chemical variation. Very preliminary work on the feldspars indicates they will require detailed microprobe study for positive identification and interpretation. A detailed mineralogic study of these problems is beyond the scope of the present report. As a result of the recognition of these mineralogic changes and problems, the author has purposely avoided using specific names for the various minerals, preferring to use the more general terms amphibole and pyroxene for the mafic minerals and perthite for feldspars. The complex warrants an in–depth microprobe study of the mineral phases (both mafic and felsic) and delineation of chemical changes that are taking place.

The petrographic descriptions accompanying this report are based on a very brief examination of the thin sections and more detailed studies with a universal stage would be useful.

A gravity survey would be helpful to determine if this alkalic rock complex is rooted in the upper mantle as has been suggested for the nearby Port Coldwell Alkalic Rock Complex. A U–Pb zircon age is desirable as well as additional isotopic studies in Pb–Pb and Nd–Sm systems.

Economic Geology

Coates (1970) has given a brief summary of all exploration activity done on the complex up to the time of his investigation. In addition to the above work, Maria Mining Corporation Limited completed 6 diamond drill holes totalling 1,256 feet in 1968 in the "Drainage Lake" area (Assessment Files Research Office, Ontario Geological Survey, Toronto). These holes were drilled on the same grid previously used by Baseline Mines Limited in 1954. The work by both Marie Mining Corporation Limited and Baseline Mines Limited disclosed minor disseminated pyrite, pyrrhotite, and chalcopyrite (Assessment Files Research Office).

In the spring of 1975, Noranda Mines Limited restaked the areas formerly held by Killala Lake Mines Limited and the area surrounding "Drainage Lake" (local name).

All of the diamond drill core remaining from drilling by Killala Lake Mines Limited in 1954 is dumped in large piles at the respective camp sites and therefore is of little value for sampling. Several core specimens that contain an estimated 5–10% disseminated sulphides were collected and tested for copper, nickel and platinum group metals (Table 7). Testing failed to disclose the presence of platinum group metals. This does not preclude their presence at Killala Lake. Low grade erratic platinum values are present at the Port Coldwell Alkalic Rock Complex (G.A. Barber, Vice President, Geology and Technology, Anaconda Company, Tuscon, Arizona, personal communication, 1976) which is located along the same fracture as the Killala Lake complex and is of similar age.

Coates (1967, p.26–26a) described sulphides in gabbro at Killala Lake as occurring in more or less discrete layers 1–3 cm thick parallel to foliation (banding). The sulphides are also confined to the felsic rather than magnetite–rich portions of the layered units (Coates 1967, p.26). Coates (1967, p.26) noted that pyrrhotite is the most abundant sulphide; chalcopyrite occurs as (1) rims on pyrrhotite, (2) as narrow haloes on gangue inclusions in the pyrrhotite and (3) rarely as fracture fillings in the pyrrhotite (Coates 1967, p.26).

Bathe (1977, p.35–42) studied the sulphide mineralogy of samples collected from drill core dumped at the campsites at Killala Lake Mines Limited He recognized pyrrhotite, chalcopyrite, cubanite, pentlandite, and valleriite. The sulphides occur interstitially and are considered by Bathe (1977, p.61) to have crystallized from an immiscible silicate–sulphide liquid solution. This solution separated from a dominantly silicate magma at high temperature and subsequently split into two liquids, one sulphide, the other silicate (Bathe 1977, p.61). The presence of

TABLE 7. COPPER AND NICKEL IN RANDOM CORE SAMPLES FROM THE KILLALA LAKE ALKALIC ROCK COMPLEX.

Sandspit Lake North			Killala Lake North		
Sample No.	Cu (ppm)	Ni (ppm)	Sample No.	Cu (ppm)	Ni (ppm)
KS-1	650	228	KP-1	1130	320
KS-2	2660	680	KP-2	1220	360
KS-3	1120	244	KP-6	1435	480
KS-4	2900	440			

Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

sulphides as interstitial grains, fracture fillings occupying cleavage planes, and as embayment features suggested to Bathe (1977, p.61) that the sulphide was the last phase to crystallize.

The oxide magnetite is reported by Bathe (1977, p.40) to be the second most common opaque mineral present. The magnetite was observed by him to occur as euhedral grains in silicate gangue minerals and sulphides and that magnetite also contains blebs of pyrrhotite and euhedral grains of silicates. The relationship suggests closely contemporaneous crystallization. Magnetite occurs as euhedral cumulus grains in silicates and sulphides, as fracture fillings in same, and as haloes around sulphide grains and as myrmekitic intergrowths with gangue minerals. Ilmenite occurs in magnetite as octahedrally oriented exsolution lamellae and as segregations (Bathe 1977, p.41–41). Since there are numerous octahedral crystals of magnetite in the sulphides, Bathe (1977, p.62) considered the magnetite to have preceded the sulphides in the order of crystallization.

Cataclastic silicates cemented with sulphide and oxide were reported by Bathe (1977, p.62).

PROPERTY DESCRIPTIONS

Table 8 summarizes exploration work on the Killala Lake complex and filed with the Assessment Files Research Office (Ontario Geological Survey, Toronto). The property descriptions are based on these records.

Baseline Mines Limited [1954]

In 1954 Baseline Mines Limited staked a series of claims in the area of "Baseline" and "Drainage" Lakes (local names) and completed a geologic survey (Assessment Files Research Office, Ontario Geological Survey). The company completed 5 diamond drill holes totalling 467 m. Two holes were drilled north of "Drainage" Lake and 3 holes south of "Drainage" Lake near the gabbro–wall-rock contact. The drilling encountered minor amounts of pyrrhotite, magnetite and chalcopyrite (see Figure 3, inset map 3). Geologic maps submitted for assessment work credit indicate occurrences of native copper, chalcopyrite and panned gold.

Killala Lake Mines Limited [1954]

Killala Lake Mines Limited explored the Killala Lake complex for base metals at two locations, one northeast of the north end of Sandspit Lake and the other northeast of the north end of Killala Lake (see Figure 3, inset maps 1 and 2).

At its Sandspit Lake location the company completed 12 diamond drill holes totalling 1418 m. At the Killala Lake location the company completed 13 diamond drill holes totalling 2352 m. This drilling disclosed minor copper and nickel

TABLE 8. EXPLORATION WORK ON THE KILLALA LAKE ALKALIC ROCK COMPLEX, FILED WITH THE ASSESSMENT FILES RESEARCH OFFICE, ONTARIO GEOLOGICAL SURVEY.

Company	File	Report
Baseline Mines Ltd.		10
Killala Lake Mines Ltd.		10,11
Maria Mining Corp. Ltd.	63.2450	11
Prospectors Airways Co. Ltd.	63A.237	

values in disseminated sulphides associated with the gabbroic phases of the complex. The best reported copper assay was 0.33% Cu over a length of 1.5 m in hole No.1 at the Sandspit Lake location. The best nickel assay was 0.16% Ni over a 2.7 m interval in hole 4–K at the Killala Lake location.

Maria Mining Corporation Limited [1968]

Maria Mining Corporation Limited completed 6 diamond drill holes totalling 382.8 m in 1968 in the "Drainage" Lake area. These holes were drilled on the same grid previously used by Baseline Mines Limited in 1954. This work disclosed minor disseminated pyrite, pyrrhotite, and chalcopyrite mineralization. The Ontario charter of the company was cancelled in 1976 (Canadian Mines Handbook, 1976–1977, p.197).

Noranda Mines Limited [1975]

In the spring of 1975, Noranda Mines Limited restaked the areas formerly held by Killala Lake Mines Limited and the area surrounding "Drainage" Lake. No work was reported by the company.

Prospectors Airways Company Limited [1954]

In 1954 the Boomerang Syndicate staked two claim groups on the Killala Lake Alkalic Rock Complex. One group of claims was located west of Barron Lake and the other group in the "Baseline–Drainage" Lakes area. An airborne magnetometer survey was completed by Canadian Aero Services of Ottawa and filed for assessment work credit by Prospectors Airways Company Limited for the Boomerang Syndicate.

Some trenching and sampling was done in the "Drainage" Lake area which returned trace to 0.03% Ni (Assessment Files Research Office, Ontario Geological Survey). The magnetic anomalies in the area are due to magnetite concentrations within the gabbro and are not related to sulphide mineralization (Coates 1970, p.31).

RECOMMENDATIONS TO THE PROSPECTOR

Of all the rocks of the complex, the gabbroic rocks appear to be the most likely to have economic potential. Exploration of the gabbroic rocks should be for disseminated sulphides. The rugged terrain combined with deep weathering of these rocks suggests that a geochemical study may be most appropriate to define areas for subsequent geophysical investigation and diamond drilling. The ruggedness of the terrain, limited access, and relatively large area to investigate would make any meaningful investigation of the complex lengthy in duration.

Closs and Sado (1978) completed a geochemical survey over a portion of the gabbro rim in the southwest corner of the complex. They analyzed samples from a small area southwest of Papaver Lake for Cu, Zn, Ni, Ba, Nb, La and P. They identified the presence of copper in an area previously drill tested by Killala Lake Mines Limited in 1954 and suggested that additional work in the area may be warranted along geochemically indicated extensions (Closs and Sado 1978, p.79–80).

Past work has concentrated on the copper and nickel possibilities and future work should pursue these metals but also investigate the possible presence of platinoid metals.

Any future work should also note that Coates (1967, p.26–26a) reported that the sulphides occur within the more felsic, magnetite–poor phases of the gabbro. Ground magnetic surveys for the isolation of drill targets should thus be used with caution.

Appendix A — Petrographic Descriptions, Chemical Analyses, Normative Compositions, and Statistical Compositions of Lithologic Units of the Killala Lake Alkalic Rock Complex.

TABLE A-1. PETROGRAPHIC AND FIELD DESCRIPTIONS OF WHOLE-ROCK SAMPLES FROM THE KILLALA LAKE ALKALIC ROCK COMPLEX*.

Map Reference No. 49
Sample No. KR7-13

Olivine, pyroxene, hornblende syenite.

Field Description. Medium to coarse grained, equigranular. Weathered surfaces are brown, fresh surfaces brown. Map Unit 6e.

Petrographic Description. Medium to coarse grained, equigranular, massive, allotriomorphic, protoclastic with embayed grain boundaries. Perthite and myrmekite are present in potassium feldspar. Feldspar grains are fractured. Brown amphibole is interstitial and commonly rims pyroxene. Olivine is generally altered to brown iddingsite and is poikilitically enclosed in the amphibole and pyroxene. Plagioclase forms clusters of anhedral grains more or less as islands in perthite, and is possibly recrystallized. Potassium metasomatism occurs along fractures.

Map Reference No. 50
Sample No. KR7-23

Olivine, pyroxene, amphibole syenite.

Field Description. Coarse grained, massive, equigranular. Weathered surfaces are brown and fresh surfaces dark green. Map Unit 6e.

Petrographic Description. Medium to coarse grained, massive, equigranular, allotriomorphic with embayed grain boundaries. Brown amphibole rims pyroxene and altered olivine; locally green amphibole (riebeckite?) rims altered olivine. Perthite and myrmekite are present. Feldspar grains are fractured. Feldspar is perthitic to antiperthitic and potassium feldspar embays the plagioclase.

Map Reference No. 51
Sample No. KR7-58

Biotite, amphibole syenite.

Field Description. Medium to coarse grained, trachytoidal. Weathered surfaces are buff and fresh surfaces buff. Map Unit 6h.

Petrographic Description. Coarse grained, massive, equigranular, hypidiomorphic. Potassium feldspars are tabular with patchy perthite replacement generally cleavage controlled. Brown amphibole is interstitial to plagioclase, and narrow rims of plagioclase occur on some potassium feldspar grains. Some feldspar grains are fractured. Minor interstitial anhedral biotite is present.

Map Reference No. 52
Sample No. KR7-66

Nepheline-bearing, pyroxene, amphibole syenite.

Field Description. Medium grained, massive, trachytoidal. Light brown on weathered surfaces and pinkish on fresh surfaces. Map Unit 6h.

Petrographic Description. Coarse grained, equigranular, massive, allotriomorphic. Brown to green-brown interstitial amphibole encloses some rounded nepheline grains and has embayed margins with potassium feldspar. Amphibole rims pyroxene. Potassium staining indicates possi-

**Reference numbers for outcrop samples are plotted on Figure 3 (Chart A).*
Note that petrographic descriptions do not always agree with the map code which is based on field observations as to the dominant lithology.

ble potassium enrichment along margins and interior to some of the feldspar grains. Rounded blebs of nepheline occur in one large potassium feldspar grain.

Map Reference No. 53
Sample No. KR7-67

Nepheline-bearing, pyroxene, amphibole syenite.

Field Description. Medium to coarse grained, massive, equigranular. Fresh surfaces are pale pink to brown-pink, weathered surfaces pink to brown. Map Unit 6e.

Petrographic Description. Coarse grained, massive, equigranular, allotriomorphic, with curved grain boundaries. Brown amphibole is interstitial and encloses pyroxene. Feldspar is a patch perthite. Minor nepheline has altered to a felty mass which, in part, is sericite. Amphibole and pyroxene contain poikilitic inclusions of apatite.

Map Reference No. 54
Sample No. KR16-17

Amphibole syenite.

Field Description. Medium grained, equigranular to slightly inequigranular, porphyritic-seriate. Weathered surfaces are red-brown, fresh surfaces red. Map Unit 6f.

Petrographic Description. Coarse grained, massive, equigranular, allotriomorphic, with straight to curved grain boundaries. Dark brown amphibole is interstitial. Plagioclase is complexly twinned; albite and pericline twins are present. Potassium feldspar is microline and has a well developed perthitic texture; it contains angular to subangular inclusions of plagioclase.

Map Reference No. 55
Sample No. KR16-31

Amphibole syenite.

Field Description. Medium grained, equigranular, massive. Weathered surfaces are brown, fresh surfaces red-brown. Map Unit 6e.

Petrographic Description. Coarse grained, massive, equigranular, allotriomorphic, with curved grain boundaries. Chlorite and actinolite are after dark brown interstitial amphibole. Feldspar is dominantly perthite which has surrounded inclusions of plagioclase. Staining indicates some potassium addition along grain boundaries and fractures. Minor fracturing of feldspar grains has occurred.

Map Reference No. 56
Sample No. KR16-37

Olivine, pyroxene syenite.

Field Description. Medium to coarse grained, equigranular to inequigranular, seriate, massive. Weathered surfaces are dark brown-grey, fresh surfaces dark grey-green. Map Unit 6e.

Petrographic Description. Fine to medium grained, massive, equigranular, allotriomorphic, with curved grained boundaries. Anhedral grains of calcic pyroxene and rounded irregular grains of olivine are set in a mosaic of fine perthitic potassium feldspar. Olivine is only very slightly altered along fractures to a dark brown unidentified mineral. Narrow myrmekitic rims on olivine suggest reaction relation with enclosing plagioclase. Feldspar grains are fractured and show some potassium metasomatism along cracks.

Map Reference No. 57
Sample No. KR16-42

Amphibole syenite.

Field Description. Coarse grained, massive, equigranular. Weathered surfaces are light brown, fresh surfaces light brown. Map Unit 6e.

Petrographic Description. Coarse grained, massive, equigranular, allotriomorphic, with embayed grain boundaries. Locally feldspar is also embayed with dark brown interstitial amphibole. Feldspar is patch perthite with embayed grain boundaries.

Map Reference No. 58
Sample No. KR16-70

Biotite, olivine, magnetite syenite.

Field Description. Coarse grained, massive, inequigranular, porphyritic, seriate. Weathered surfaces are brown, fresh surfaces pink. Map Unit 6e.

Petrographic Description. Coarse grained, equigranular, massive, allotriomorphic, with curved to embayed grain boundaries. Biotite forms very narrow rims on irregular magnetite grains.

Olivine forms rounded grains with slight brownish alterations. Apatite is poikilitic in magnetite. Perthite grains appear to be fractured; anorthite content is approximately 34% on several grains.

Map Reference No. 59
Sample No. KR16-97

Amphibole syenite.

Field Description. Coarse grained, trachytoidal. Weathered surfaces are buff, fresh surfaces are buff to pink. Map Unit 6h.

Petrographic Description. Coarse grained, massive, equigranular, allotriomorphic, with curved to straight grain boundaries. Nepheline is deeply stained, possibly because of high kalsilite molecule content. Perthite has patchy staining and staining along fractures. Possibly some potassium metasomatism has taken place. Dark brown to brown-green interstitial amphibole rims subrounded pyroxene grains. Apatite is poikilitic within and marginal to interstitial amphibole and magnetite.

Map Reference No. 60
Sample No. KR16-99

Nepheline-bearing, amphibole syenite.

Field Description. Medium to coarse grained, trachytoidal. Weathered and fresh surfaces are buff. Map Unit 6h.

Petrographic Description. Coarse grained, massive, equigranular, allotriomorphic, with embayed grain boundaries. Pyroxene forms small rounded grains enclosed in green-brown amphibole. Nepheline forms rounded to irregular grains along or between perthitic grains. Dark green-brown amphibole is interstitial and rims pyroxene. Perthite is patchy. Feldspar is a product of a hypersolvus exsolution.

Map Reference No. 61
Sample No. KR17-8

Biotite, magnetite, amphibole syenite.

Field Description. Coarse grained, massive, equigranular. Weathered and fresh surfaces are light brown. Map Unit 6e.

Petrographic Description. Coarse grained, equigranular, massive, allotriomorphic, with curved to straight grain boundaries. Mafic minerals are interstitial. Irregular magnetite grains are partially rimmed with dark brown amphibole which is rimmed in turn with biotite. Plagioclase is clouded and interstitial. Perthite is a patch perthite.

Map Reference No. 62
Sample No. KR18-24

Amphibole syenite.

Field Description. Coarse grained, equigranular, massive. Buff on both fresh and weathered surfaces. Map Unit 6d.

Petrographic Description. Coarse grained, massive, equigranular, allotriomorphic, with straight to curved grain boundaries. Dark brown interstitial amphiboles contain irregular rounded pyroxene grains in cores. Feldspar is a patch perthite with subrounded to subangular blebs of plagioclase. Plagioclase blebs are larger than in most thin sections. Minor cloudy interstitial plagioclase is present.

Map Reference No. 63
Sample No. KR18-32

Amphibole syenite.

Field Description. Coarse grained, massive, equigranular. Weathered and fresh surfaces are buff. Map Unit 6d.

Petrographic Description. Coarse grained, equigranular, massive, allotriomorphic, with straight to curved grain boundaries. Dark brown interstitial amphibole occurs with interstitial apatite and magnetite. Feldspar is a very fine perthitic feldspar with rounded to subrounded patches of clear to cloudy plagioclase. Minor highly altered interstitial nepheline is present. Plagioclase (An39?) forms an anhedral mosaic interstitial to larger perthite grains. Plagioclase grains are commonly fractured and twinning displays minor offsets.

Map Reference No. 64
Sample No. KR18-49

Biotite, amphibole syenite.

Field Description. Coarse grained, massive, equigranular. Fresh and weathered surfaces are buff. Map Unit 6d.

Petrographic Description. Coarse grained, equigranular, allotriomorphic, with straight to curved grain boundaries. Dark brown interstitial amphibole is partly replaced by dark brown biotite. Stringy perthite is very finely exsolved with strongest staining in areas of greatest alteration, probably fine-grained sericite. Possibly some potassium metasomatism has occurred, since staining is more intense along cleavage directions. Minor clouded interstitial plagioclase is present.

Map Reference No. 65
Sample No. KR18-54

Olivine, pyroxene, amphibole syenite.

Field Description. Fine to coarse grained, inequigranular, porphyritic-seriate, massive. Fresh surfaces are mottled pink and grey, weathered surfaces grey with pink spotting. Map Unit 6e.

Petrographic Description. Fine to medium grained, inequigranular, porphyritic-seriate, allotriomorphic, with curved to straight grain boundaries. Bead-like olivine grains, both fresh and altered to dark brown iddingsite(?), are poikilitically included in amphibole. Pyroxene forms small irregular grains within the larger amphibole grains and large grains rimmed with dark brown amphibole. Apatite is poikilitic in amphibole. Feldspars lack evidence of twinning and display well developed potassium staining along fractures which locally are pervasive.

Map Reference No. 66
Sample No. KR18-62

Amphibole syenite.

Field Description. Coarse grained, massive, equigranular. Interstitial mafic minerals have a subophitic textural relationship with the feldspars. Weathered surfaces are red and fresh surfaces red-brown. Map Unit 6e.

Petrographic Description. Coarse grained, massive, inequigranular, allotriomorphic, with straight to curved grain boundaries. Dark brown amphibole is interstitial and some has subangular inclusions of perthite. Perthite is patchy and probably a hypersolvus replacement.

Map Reference No. 67
Sample No. KR21-30

Amphibole syenite.

Field Description. Coarse grained, equigranular, massive. Weathered surfaces and fresh surfaces are buff. Map Unit 6d.

Petrographic Description. Coarse grained, equigranular, massive, allotriomorphic, with curved to embayed grain boundaries. Dark brown to greenish brown amphibole forms irregular interstitial composite grains, locally with a little biotite along peripheries of grains. Plagioclase forms interstitial anhedral mosaics between larger perthite grains; twinning is often poorly developed. Perthite is patchy and approaches antiperthite in some grains. The perthite texture represents hypersolvus exsolution.

Map Reference No. 68
Sample No. KR21-44

Pyroxene, amphibole syenite.

Field Description. Coarse grained, massive, equigranular. Fresh surfaces are buff to pale pink. Map Unit 6d.

Petrographic Description. Coarse grained, equigranular, allotriomorphic, with curved to embayed grain boundaries. Pyroxene is thickly mantled with dark brown amphibole. Amphibole is interstitial forming irregular composite grains. Plagioclase forms mosaics of anhedral, poorly twinned grains interstitial to the larger perthitic grains. Potassium staining suggets potassium enrichment along fractures and cleavage planes.

Map Reference No. 69
Sample No. KR21-50

Olivine gabbro.

Field Description. Medium grained, massive, equigranular. The outcrop has been intruded extensively by buff to pink coarse grained amphibole syenite. The exposure consists of gabbro blocks in syenite. Both fresh and weathered surfaces are blue-grey. Map Unit 4a.

Petrographic Description. Medium grained, massive, equigranular, allotriomorphic, with curved to straight grain boundaries. Plagioclase (An57) forms an interlocking mosaic. Pyroxene is interstitial and commonly has a narrow rim of actinolitic amphibole. Olivine forms irregular grains within an interlocking mat of talc grains. Amphibole occurs only as rims on pyroxene.

Map Reference No. 70
Sample No. KR21-73

Troctolite.

Field Description. Medium grained, massive, equigranular. Weathered surfaces are brown, fresh surfaces dark grey-green. Map Unit 4b.

Petrographic Description. Medium grained, massive, equigranular, allotriomorphic, with curved to straight grain boundaries. Amphibole is a light pale green colour and interstitial containing or enclosing some olivine and magnetite grains. Plagioclase (An64) forms an interlocking anhedral mosaic. Olivine grains are enclosed in alteration haloes which are very fine grained and may contain talc, amphibole and untwinned plagioclase. Subangular grains of magnetite may have narrow rims of biotite. Fractures in rock contain sericite alteration.

Map Reference No. 71
Sample No. KR21-92

Larvikite.

Field Description. Medium grained, massive, equigranular. Weathered surfaces are brown, fresh surfaces blue-grey. Map Unit 4c.

Petrographic Description. Medium grained, equigranular, massive, allotriomorphic, with curved to straight grain boundaries. Irregular grains of magnetite have narrow rims of biotite. Olivine grains are rounded and clustered with pyroxene. Some red-brown staining occurs along fractures in grains. Pyroxene forms rounded to subrounded interstitial grains with incipient alteration along rims. Feldspar shows little evidence of twinning and is relatively unstained; potassium staining occurs along fractures parallel to cleavage and grain boundaries.

Map Reference No. 72
Sample No. KR21-107

Amphibole, nepheline syenite.

Field Description. Medium grained, equigranular, massive. Both weathered and fresh surfaces are buff. Map Unit 6i.

Petrographic Description. Coarse grained, massive, equigranular, allotriomorphic, with straight to curved grain boundaries. Dark brown interstitial amphibole is zoned from slightly lighter brown cores to darker brown rims. Amphibole encloses small plagioclase crystals. Nepheline forms a highly altered, deeply stained, isotropic to slightly anisotropic mass. Patchy perthite is anhedral and well developed.

Map Reference No. 73
Sample No. KR21-112

Pyroxene, amphibole, biotite, nepheline syenite.

Field Description. Coarse grained, massive, equigranular. Weathered surfaces are buff to grey-white, fresh surfaces buff. Map Unit 6d.

Petrographic Description. Coarse grained, equigranular, allotriomorphic, with embayed grain boundaries. Pyroxene occurs as anhedral grains rimmed with green amphibole. Amphibole is irregular, slightly acicular, and centrally located to biotite clusters. Biotite forms interlocking booklets enclosing amphibole. Nepheline is highly altered and stained for potassium; it is isotropic or weakly anisotropic. Perthite is patchy, and likely a replacement of sodic plagioclase.

Map Reference No. 74
Sample No. KR21-159

Gabbro.

Field Description. Very fine grained, massive, equigranular. Weathered surfaces are brown, fresh surfaces dark grey. Map Unit 4d.

Petrographic Description. Fine grained, massive, equigranular, allotriomorphic, with curved to embayed grain boundaries. Pyroxene forms anhedral, irregular grains. Magnetite forms angular to subrounded grains rimmed with biotite. Biotite occurs as tiny booklets rimming magnetite grains. Amphibole occurs as pale green grains mixed in with the pyroxene grains. Plagioclase (An54) forms lath-like crystals with embayed margins and ends.

Map Reference No. 75
Sample No. KR21-162

Gabbro.

Field Description. Medium grained, equigranular, massive. The outcrop is cut by small dikes of syenite. Weathered surfaces are grey-brown, fresh surfaces blue-grey. Map Unit 4a.

Petrographic Description. Medium grained, massive, equigranular, allotriomorphic, with straight to curved grain boundaries. Chlorite forms interlocking felty blue-green masses, possibly after olivine. Alteration along boundaries of chlorite clots with plagioclase suggest very fine intergrowth of amphibole and plagioclase. Magnetite has very thin rims of biotite. Pyroxene is interstitial with oriented inclusions resembling a schiller texture. The oriented inclusions resemble amphibole cleavage pattern. Plagioclase (An56) forms an interlocking mosaic of tabular crystals. Very narrow reaction rims of pale green amphibole (?) occur between plagioclase and pyroxene.

Map Reference No. 76
Sample No. KR21-169B

Olivine gabbro.

Field Description. Medium grained, equigranular, massive. The outcrop is extensively intruded by nepheline-bearing syenite. Weathered surfaces are brown, fresh surfaces dark grey. Map Unit 4a.

Petrographic Description. Medium grained, equigranular, massive, allotriomorphic, with straight to curved grain boundaries. Pyroxene forms anhedral interstitial grains with low extinction angles and abundant oriented dark inclusions similar to schiller texture. Pyroxene may be inverted enstatite. Traces of light green amphibole occur on rims of some grains. Olivine forms anhedral irregular to rounded grains. Light brown alteration occurs along fractures in some olivine grains and light green amphibole commonly forms thin rims on other grains. Plagioclase (An55) is fresh and forms an interlocking mosaic of tabular crystals.

Map Reference No. 77
Sample No. KR21-171

Olivine gabbro.

Field Description. Medium grained, equigranular, massive. The outcrop is cut by syenite dikes. Weathered surfaces are blue-grey to brown, fresh surfaces blue-grey. Map Unit 4a.

Petrographic Description. Medium grained, equigranular, allotriomorphic, with straight to curved grain boundaries. Plagioclase (An47) forms an interlocking mosaic of tabular crystals. Pyroxene forms fresh anhedral grains which locally have thin rims of light green amphibole. Olivine forms irregular rounded grains which locally display well developed rims of light green amphibole. Some grains are enclosed in micaceous chlorite. Locally some myrmekite formed as reaction with plagioclase. Myrmekite appears to be a very fine intergrowth of amphibole and untwinned plagioclase.

Map Reference No. 78
Sample No. KR21-173B

Biotite, amphibole, pyroxene syenite (mafic).

Field Description. Medium to coarse grained, inequigranular. Mafic minerals have a subophitic texture with the feldspar. Both weathered and fresh surfaces are pinkish in colour. Map Unit 6e.

Petrographic Description. Medium grained, equigranular, massive, allotriomorphic, with straight to curved grain boundaries. Pyroxene occurs as anhedral grains mantled with green-brown to brown-green amphibole. Some amphibole rims magnetite. Plagioclase (An30) forms anhedral mosaics of interstitial grains. Perthite is patchy and possibly a replacement of earlier formed sodic plagioclase.

Map Reference No. 79
Sample No. KR21-203

Amphibole syenite.

Field Description. Coarse grained, massive, equigranular. Amphibole is subophitic with respect to feldspar. Weathered and fresh surfaces are buff in colour. Map Unit 6d.

Petrographic Description. Coarse grained, massive, equigranular, allotriomorphic, with straight to curved grain boundaries. Biotite rims magnetite and some amphibole; some biotite occurs as isolated grains. Amphibole forms dark brown, irregular, interstitial grains. Pyroxene occurs rarely as isolated grains mantled with amphibole. Plagioclase (An 31?) occurs as clouded, interstitial, anhedral mosaics. Perthite is a patch perthite. Staining indicates potassium along cleavage planes and fractures cutting feldspars grain.

Map Reference No. 80
Sample No. KR21-233

Biotite, amphibole syenite.

Field Description. Coarse grained, massive, inequigranular to porphyritic-seriate. Weathered and fresh surfaces are brown in colour. Map Unit 6e.

Petrographic Description. Coarse grained, equigranular, massive, allotriomorphic, with straight to curved grain boundaries. Olivine occurs as rounded grains in part altered to a deep red-brown mineral, possibly iddingsite (?). Biotite is interstitial and commonly associated with irregular magnetite grains. Amphibole is green-brown to brown-green, commonly occurring as interstitial grains. Amphibole rims olivine and is commonly associated with biotite. Plagioclase (An 38?) occurs as interstitial anhedral mosaics between perthite; trace amounts of interstitial microcline are also present. Perthite is patchy, and potassium staining indicates potassium enrichment along fractures, grain boundaries, and grain margins.

Map Reference No. 81
Sample No. KR22-68B

Amphibole syenite.

Field Description. Coarse grained, massive, equigranular. Weathered and fresh surfaces are white. Map Unit 6d.

Petrographic Description. Coarse grained, equigranular, allotriomorphic, with curved to straight grain boundaries. Traces of deeply altered and stained nepheline form a felty mass of irregular bulbous shape. Amphibole is dark brown to green-brown, interstitial, and encloses random plagioclase grains. Interstitial plagioclase forms an anhedral mosaic of interlocking grains.

Map Reference No. 82
Sample No. KR22-110

Biotite, amphibole syenite.

Field Description. Coarse grained, massive, inequigranular to porphyritic-seriate. Weathered surfaces are brown, fresh surfaces white. Map Unit 6d.

Petrographic Description. Coarse grained, massive, equigranular, allotriomorphic to hypidiomorphic, with straight to curved grain boundaries. Pyroxene is rare and thickly mantled with amphibole. Biotite forms clots mixed with anhedral green-brown to brown-green amphibole. Plagioclase (An 36) forms an interlocking mosaic of grains, generally with fresh-looking fractures; protoclastic texture is common. Perthite is patchy and contains poikilitic inclusions of smaller plagioclase grains.

Map Reference No. 83
Sample No. KR22-122

Biotite, amphibole syenite.

Field Description. Fine to coarse grained, inequigranular to porphyritic-seriate. Feldspar phenocrysts visually comprise 25-30% of the rock. Weathered surfaces are rust-brown, fresh surfaces grey-brown. Map Unit 7a.

Petrographic Description. Medium grained, massive, inequigranular to porphyritic-seriate, allotriomorphic to hypidiomorphic, with straight to curved grain boundaries. Amphibole forms dark brown to green-brown irregular interstitial grains. Biotite is commonly associated with amphibole. Plagioclase (An 30?) forms interstitial interlocking mosaics with perthite grains and commonly is slightly sericitized. Perthite forms large irregular phenocrysts with inclusions at plagioclase and is dominant in the ground mass. Perthite is stringy.

Map Reference No. 84
Sample No. KR22-135

Biotite syenite.

Field Description. Coarse grained, inequigranular to porphyritic-seriate. Weathered surfaces are light grey, fresh surfaces pink-grey. Map Unit 6d.

Petrographic Description. Coarse grained, massive, equigranular, hypidiomorphic. Biotite forms felty interstitial aggregates with possibly some dark brown limonite. Plagioclase is clouded and finely twinned. Crystal outlines are evident on some plagioclases. Perthite is patchy and clearly interstitial to the plagioclase.

Map Reference No. 85
Sample No. KR23-3B

Monzonite.

Field Description. Fine to coarse grained, inequigranular to porphyritic-seriate, massive. Feldspar phenocrysts comprise about 10% of the rock. Weathered surfaces are brown, fresh surfaces blue-grey. Map Unit 5a.

Petrographic Description. Fine to medium grained, inequigranular to porphyritic-seriate, allotriomorphic, with curved to straight grain boundaries. Potassium feldspar phenocrysts have

well developed Carlsbad twins, ragged edges and contain plagioclase inclusions along edges. Olivine occurs as irregular crudely rounded grains enclosed in pyroxene and mantled by amphibole. Pyroxene is present as irregular interstitial grains mantled by amphibole. Amphibole forms irregular green-brown to brown anastomosing grains which mantle the pyroxene. The plagioclase (An 32) is untwinned to twinned and forms an interlocking mosaic of interlocking grains. Potassium stain along fractures in feldspar suggests some migration of potassium.

Map Reference No. 86
Sample No. KR23-33

Biotite, amphibole monzonite (mafic).

Field Description. Medium grained, equigranular, massive. Weathered and fresh surfaces are mottled grey to buff. Map Unit 5b.

Petrographic Description. Medium grained, equigranular, hypidiomorphic. Apatite is poikilitic in mafic minerals. Olivine forms anhedral rounded grains altering to dark brown to red-brown iddingsite. Pyroxene occurs as irregularly shaped relict cores with thick manties of amphibole. Amphibole occurs as dark brown to green-brown, irregular, anhedral interstitial grains. Biotite rims magnetite and is associated with the amphibole. Plagioclase (An32) occurs as distinct tabular grains with some anhedral outlines. Cryptoperthite forms an interlocking mosaic of grains with plagioclase.

Map Reference No. 87
Sample No. KR23-70

Amphibole syenite.

Field Description. Medium to coarse grained, massive, equigranular. Weathered and fresh surfaces are red-brown. Map Unit 6e.

Petrographic Description. Coarse grained, massive, equigranular, allotriomorphic to hypidiomorphic, with curved to straight grain boundaries. Amphibole is dark green to green-brown, interstitial, with poikilitic magnetite and apatite. Perthite is patchy and rarely stringy. Perthite is anhedral and interstitial to plagioclase. Plagioclase (An32) is generally anhedral but locally shows crystal faces.

Map Reference No. 88
Sample No. KR23-82A

Amphibole syenite.

Field Description. Coarse grained, massive, equigranular. Weathered surfaces are brown, fresh surfaces buff. Map Unit 6f.

Petrographic Description. Coarse grained, massive, equigranular, allotriomorphic to slightly hypidiomorphic, with straight and curved grain boundaries. Traces of zeolitic (?) alteration are present. Amphibole is dark brown, interstitial and encloses some smaller plagioclase grains. Rarely biotite rims some amphibole. Plagioclase forms subhedral grains, which are often poikilitic in perthite and are clouded. Sometimes the enclosed grains look angular, as if they had been brecciated before incorporation in perthite. Perthite is patchy and locally interstitial to plagioclase.

Map Reference No. 89
Sample No. KR23-90

Monzonite.

Field Description. Fine to medium grained, massive, equigranular to porphyritic-seriate. Feldspar phenocrysts form about 10-15% of the rock. Weathered surfaces are light grey, fresh surfaces dark grey. Map Unit 5a.

Petrographic Description. Medium grained, massive, inequigranular to porphyritic-seriate, allotriomorphic, with straight to curved grain boundaries. Rounded to subrounded phenocrysts are stringy perthite. Apatite is poikilitic in amphibole. Amphibole forms dark brown, irregular interstitial grains. Olivine is rare and occurs as rounded grains mantled with amphibole. Groundmass feldspar is likely a very fine-grained stringy perthite. No albite twinning was noted. Perthite forms a mosaic of anhedral grains with curved boundaries. Potassium stain suggests potassium along grain boundaries and fractures. The rock may have been metasomatized or subjected to deuteric processes.

Map Reference No. 90
Sample No. KR23-113A

Mozonite.

Field Description. Fine to medium grained, massive, inequigranular to porphyritic-seriate. Feldspar phenocrysts form about 5% of the rock. Weathered surfaces are buff, fresh surfaces dark grey. Map Unit 5a.

Petrographic Description. Medium grained, massive, inequigranular to porphyritic–seriate, allotriomorphic to hypidiomorphic, with curved to straight grain boundaries. Phenocrysts are the only euhedral crystals. Dark brown to green–brown, amoeboid amphibole has a sieve texture, and contains clouded, rounded plagioclase grains. Olivine forms rounded irregular fresh grains. Pyroxene occurs rarely as relict cores mantled with amphibole. Schiller texture is present in relict grains. Feldspars form an anhedral mosaic with curved grain boundaries. Intense potassium stain was noted along grain margins.

Map Reference No. 91
Sample No. KR23–134

Amphibole syenite.

Field Description. Coarse grained, slightly porphyritic. Weathered surfaces are brown, fresh surfaces pink. Map Unit 6e.

Petrographic Description. Coarse grained, massive, equigranular, hypidiomorphic. Dark brown interstitial amphibole encloses occasional apatite or magnetite grains. Plagioclase is anhedral to subhedral, commonly fractured and thus slightly protoclastic. Perthite is patchy and interstitial to the plagioclase. Biotite is associated with amphibole. Biotite clots with scattered magnetite in central area may be after former olivine.

Map Reference No. 92
Sample No. KR23–149

Biotite, amphibole syenite.

Field Description. Coarse grained, equigranular. Weathered and fresh surfaces are red–brown in colour. Map Unit 6f.

Petrographic Description. Coarse grained, massive, equigranular, allotriomorphic, with curved to straight grain boundaries. Muscovite interstitial to feldspar appears to be very late in order of crystallization. Biotite occurs as discrete grains and in association with amphibole where it possibly results from an alteration of amphibole. Amphibole is green–brown to brown, and interstitial to the feldspar. Grains are irregular in outline and anastomosing. Olivine occurs as poikilitic inclusions in the amphibole and is altered to dark brown iddingsite. Plagioclase (An32) forms an interlocking mosaic of anhedral grains with sometimes diffuse or absent albite twinning. Plagioclase displays some bending of twin planes and is thus protoclastic. Perthite is irregular, anastomosing, interstitial to the plagioclase and encloses some plagioclase fragments.

Map Reference No. 93
Sample No. KR23–248

Monzonite.

Field Description. Medium grained, inequigranular to porphyritic–seriate. Pink feldspar phenocrysts form 5–10% of the rock. The rock is slightly magnetic. Weathered surfaces are grey, fresh surfaces grey with pink mottling. Map Unit 5a.

Petrographic Description. Fine grained, equigranular, massive, allotriomorphic, with curved to straight grain boundaries. Apatite occurs as poikilitic crystals in pyroxene and amphibole. Olivine forms rounded to irregular grains within and associated with pyroxene and amphibole. Magnetite forms irregular anastomosing grains associated with amphibole, pyroxene and olivine and probably results in part from the alteration of the pyroxene or olivine. Amphibole forms green–brown to brown rims on relict pyroxene and olivine and forms irregular anatomosing grains with poikilitic amphibole and plagioclase. Pyroxene forms irregular relicts mantled with amphibole. Plagioclase (An37) is untwinned to twinned and forms an interlocking anhedral mosaic of crystals; staining suggests some potassium along fractures.

Map Reference No. 94
Sample No. KR23–273

Amphibole syenite.

Field Description. Coarse grained, equigranular, massive. Amphibole has well developed subophitic texture with feldspars. Weathered surfaces are pink, fresh surfaces brown. Map Unit 6e.

Petrographic Description. Coarse grained, massive, equigranular, allotriomorphic, with curved grain boundaries. Dark brown amphibole is interstitial to feldspar and poikilitically encloses some rounded grains of plagioclase. Plagioclase occurs as an interlocking mosaic of anhedral crystals.

Map Reference No. 95
Sample No. KR23–274

Monzonite.

Field Description. Medium grained, inequigranular to porphyritic–seriate, hypidiomorphic. Weak trachytoidal texture. Tabular feldspar phenocrysts form 10–15% of rock. Weathered surfaces are grey with pink spots, fresh surfaces mottled pink and grey. Map Unit 5a.

Petrographic Description. Fine grained, equigranular, allotriomorphic, with curved to straight grain boundaries. Pyroxene forms irregular grains mantled by amphibole and is interstitial to the feldspar. Amphibole is green-brown to brown and forms irregular anastomosing grains enclosing relict pyroxene and partially enclosing some plagioclase. Untwinned to twinned, anhedral plagioclase (An34) grains form irregular interlocking mosaics. The somewhat larger perthite crystals contain poikilitic angular plagioclase inclusions and under very high magnification appear to be stringy. Olivine forms rounded irregular grains associated with pyroxene and partially altered to amphibole. Potassium staining was noted along grain boundaries and fractures.

Map Reference No. 96
Sample No. KR23-288

Amphibole syenite.

Field Description. Coarse grained, equigranular, massive. The outcrop has very well developed mafic segregation banding. The sample was taken from homogeneous interband area. Weathered and fresh surfaces are red. Map Unit 6e.

Petrographic Description. Coarse grained, massive, equigranular, hypidiomorphic. Dark brown interstitial amphibole partially encloses rounded plagioclase grains. The contact of amphibole with perthite is straight, implying perthite has crystal faces. Perthite is patchy with a little exsolutional plagioclase. Grains are anhedral with interstitial amphibole filling. Plagioclase forms rounded grains partially enclosed in perthite. Plagioclase grains are protoclastic with incipient sericite development along cracks.

Map Reference No. 97
Sample No. KR23-356

Amphibole syenite.

Field Description. Coarse grained, massive, equigranular. The feldspars show weak schiller. Weathered surfaces are pinkish, fresh surfaces buff to pinkish. Map Unit 6e.

Petrographic Description. Coarse grained, massive, equigranular, hypidiomorphic. Amphibole is dark green-brown, interstitial and contains poikilitic apatite; a trace of magnetite possibly after olivine was noted in one amphibole grain. Plagioclase is subhedral to anhedral and displays protoclastic textures. Fractures display incipient development of sericite. Perthite is both patchy and stringy. Perthite has crude crystal outline next to amphibole.

Map Reference No. 98
Sample No. KR25-5

Noritic gabbro.

Field Description. Very fine grained, massive, equigranular. Weathered surfaces are dark brown, fresh surfaces dark grey. Map Unit 4d.

Petrographic Description. Fine grained, equigranular, massive, allotriomorphic, granoblastic. The rock appears to be recrystallized. Plagioclase and pyroxene (principally diopside) form an interlocking mosaic of grains. Hypersthene is present in subordinate amounts.

Map Reference No. 99
Sample No. KR25-9

Pyroxene-bearing troctolite.

Field Description. Medium to coarse grained, equigranular, massive. Weathered and fresh surfaces are blue-grey. Map Unit 4b.

Petrographic Description. Medium grained, massive, equigranular, hypidiomorphic. Magnetite forms irregular grains often with biotite along rims. Olivine forms subrounded grains with dark brown alteration along fractures. Pyroxene forms irregular grains. Bent twin lamellae on plagioclase are common; plagioclase has protoclastic texture.

Map Reference No. 100
Sample No. KR25-12

Pyroxene-bearing troctolite.

Field Description. Coarse grained, massive, equigranular. Weathered surfaces are brown, fresh surfaces blue-grey. Map Unit 4b.

Petrographic Description. Medium grained, equigranular, massive, hypidiomorphic. Biotite occurs after olivine and rims magnetite. Pyroxene forms irregular interstitial grains with narrow reaction rims of interdigitating light green amphibole and untwinned plagioclase. Olivine is in part altered to magnetite, biotite and an interdigitating myrmekite of light green amphibole and

untwinned plagioclase. Myrmekite forms a major phase and consists of oriented intergrowth of light green amphibole and untwinned plagioclase which is best developed around olivine grains. Plagioclase forms an interlocking mosaic of fresh tabular crystals and shows uncommon crystal outlines in contact with pyroxene.

Map Reference No. 101
Sample No. KR25-19

Olivine gabbro.

Field Description. Medium grained, massive, equigranular. Outcrop is veined with coarse grained syenite. Weathered surfaces are rusty brown, fresh surfaces dark grey. Map Unit 4a.

Petrographic Description. Medium grained, equigranular, massive, allotriomorphic, with curved to straight grain boundaries. Biotite and light green amphibole occur as alteration along rims of olivine grains. Olivine forms irregular grains closely associated with pyroxene, and has a deep red-brown alteration along fractures. Pyroxene is interstitial and consists of irregular grains with moderately developed schiller texture. Plagioclase (An62) forms an interlocking mosaic of anhedral grains.

Map Reference No. 102
Sample No. KR25-20B

Gabbro.

Field Description. Medium grained, equigranular, massive. Locally gabbro is extensively diked with coarse-grained syenite. Weathered surfaces are light to dark brown, fresh surfaces grey to blue-grey. Map Unit 4a.

Petrographic Description. Medium grained, equigranular, massive, allotriomorphic. Pyroxene is interstitial and invariably rimmed with light green amphibole. Amphibole forms light green rims on pyroxene and also occurs as discrete grains after pyroxene. Magnetite is skeletal and commonly associated with green amphibole and some chlorite. This magnetite alteration is probably after olivine. Complex intergrowths of amphibole and plagioclase are present along margins of some pyroxene grains and sites of former olivine. Weakly fractured plagioclase (An 64) forms an interlocking mosaic of tabular crystals. Plagioclase is flecked with sericite, particularly along fractures and grain margins.

Map Reference No. 103
Sample No. KR25-36

Gabbro.

Field Description. Medium grained, equigranular, massive. Weathered and fresh surfaces are grey. Map Unit 4a.

Petrographic Description. Medium grained, equigranular, massive, allotriomorphic, with straight to curved grain boundaries. Pyroxene is interstitial and locally encloses small crystals of plagioclase. Traces of biotite occur along margins of some pyroxene grains. Traces of light green amphibole occur along margins of some pyroxene grains and along peripheries of the occasional olivine. Olivine is altered to deep brown iddingsite (?). Plagioclase (An 50) forms an anhedral mosaic of interlocking grains. Minor sericite alteration occurs along grain margins of feldspars.

Map Reference No. 104
Sample No. KR28-23

Larvikite.

Field Description. Medium grained, equigranular, massive. Weathered and fresh surfaces are blue-grey. Map Unit 4c.

Petrographic Description. Medium grained, massive, equigranular, allotriomorphic, with straight to curved grain boundaries. Olivine occurs as rounded grains partially altered along margins and cracks to dark brown iddingsite. Magnetite occurs as disseminated grains commonly associated with olivine. Pyroxene is clouded, displaying a weak to moderate schiller texture. Traces of apatite occur in pyroxene and olivine. Plagioclase (An32) forms ghosts within centres of larger feldspar grains. The dominant feldspar is very fine grained string perthite. Potassium staining is most intense along grain margins, cleavages and fractures.

Map Reference No. 105
Sample No. KR28-30

Biotite, amphibole, nepheline syenite.

Field Description. Coarse grained, equigranular, massive. Amphibole is subophitic with respect to the feldspars. Weathered and fresh surfaces are pink in colour. Map Unit 6h.

Petrographic Description. Medium grained, massive, allotriomorphic, with straight to curved grain boundaries. Nepheline is highly altered, possibly to some zeolite mineral in addition to sericite. Altered interstitial nepheline takes an intense stain for potassium. Plagioclase (An 35) occurs as patches in the perthite. Perthite is stringy; minor amounts of patch perthite are present. Pyroxene occurs as relicts thickly mantled with amphibole. Amphibole occurs as green-brown to brown-green interstitial grains with traces of poikilitic apatite. Trace amounts of sericite and carbonate occur in association with one grain of amphibole.

Map Reference No. 106
Sample No. KR28-35

Olivine gabbro.

Field Description. Medium grained, equigranular, massive. Weathered and fresh surfaces are dark grey in colour. Map Unit 4a.

Petrographic Description. Medium grained, equigranular, massive, hypidiomorphic. Magnetite forms disseminated, irregular, anastomosing grains between pyroxene and olivine grains. Pyroxene is calcic and forms an interlocking anhedral mosaic of rounded grains which in places partially enclose plagioclase grains. Olivine forms irregular grains in association with pyroxene and has a dark brown alteration along some fractures. Plagioclase (An62) forms an interlocking mesh which commonly displays bent twin lamellae; it has a protoclastic texture. Biotite forms narrow rims on olivine and magnetite grains and a light green amphibole forms a narrow rim on the pyroxene. The pyroxene commonly has oriented inclusions typical of a schiller texture.

Map Reference No. 107
Sample No. KR28-42

Larvikite.

Field Description. Medium to coarse grained, equigranular, massive. Weathered surfaces are rusty brown, fresh surfaces blue-grey. Map Unit 4c.

Petrographic Description. Medium grained, massive, equigranular, allotriomorphic, with straight to curved grain boundaries. Plagioclase appears as ghost relicts in cores of untwinned (perthitic?) feldspar. Olivine forms rounded grains in association with magnetite and pyroxene. Olivine is altered to a deep red-brown mineral. Apatite is poikilitic in pyroxene. Pyroxene forms anhedral rounded interstitial grains with some schiller texture. Perthites are stringy and resolvable only at highest power magnification. Perthites have areas of relict plagioclase twinning with diffuse boundaries grading into untwinned feldspar. Magnetite forms rounded grains in association with pyroxene and olivine.

Map Reference No. 108
Sample No. KR30-11

Amphibole syenite.

Field Description. Coarse grained, equigranular, massive. Trace amounts of biotite are present. Weathered and fresh surfaces are buff in colour. Map Unit 6d.

Petrographic Description. Coarse grained, massive, equigranular, allotriomorphic, with straight to curved grain boundaries. Perthite is patchy locally containing angular crystal fragments and crystals of turbid plagioclase. Amphibole is dark green-brown to brown-green and interstitial to the feldspars; it contains poikilitic apatite and minor associated biotite. Plagioclase forms anhedral interstitial mosaics, sometimes projecting into the perthite. Twin planes are bent, defining a protoclastic texture.

Map Reference No. 109
Sample No. KR31-21

Amphibole syenite.

Field Description. Coarse grained, massive, equigranular. Minor biotite is present. Weathered surfaces are pink and fresh surfaces are pink to brown. Map Unit 6d.

Petrographic Description. Coarse grained, massive, equigranular, allotriomorphic, with curved to straight grain boundaries. Apatite is poikilitic in amphibole. Dark brown to green-brown interstitial amphibole encloses turbid plagioclase grains that are angular in outline. Biotite is interstitial to amphibole and occurs along amphibole grain margins. Perthite is patchy and sometimes contains turbid crystal and crystal fragments of plagioclase. Plagioclase is poorly to only faintly twinned. Olivine is poikilitic in amphibole and altered to a deep red-brown.

Map Reference No. 110
Sample No. KR31-39

Biotite, nepheline, amphibole syenite.

Field Description. Coarse grained, equigranular, massive. Some mafic segregation banding is evident on outcrop surface. Weathered surfaces are white to buff and fresh surfaces pink-brown. The sample was taken from homogeneous portion of the outcrop. Map Unit 6d.

Petrographic Description. Coarse grained, massive, equigranular, massive, allotriomorphic, with curved to straight grain boundaries. Biotite forms marginal to the amphibole and rarely between the feldspar grains. Pyroxene is relict and heavily mantled with amphibole. Plagioclase is unstained, generally displaying only weak twinning. Amphibole is dark brown to green-brown, interstitial to the feldspar and contains poikilitic apatite and relict pyroxene. Nepheline is highly altered and intensely stained. Nepheline is interstitial. Perthite is patchy consisting of very irregular anhedral grains. Perthite shows potassium staining along grain margins and fractures.

Map Reference No. 111
Sample No. KR31-49

Amphibole syenite.

Field Description. Coarse grained, equigranular, massive. Weathered surfaces are buff to grey-white, fresh surfaces buff to pale pink. Map Unit 6d.

Petrographic Description. Coarse grained, massive, equigranular, allotriomorphic, with curved to straight grain boundaries. Dark brown to green-brown amphibole contains traces of poikilitic olivine (altered) and apatite. Amphibole is interstitial. Plagioclase is weakly twinned. Perthite is a coarse patch perthite and some grains contain subangular to angular grains of turbid plagioclase. Weak bending of plagioclase twin lamellae suggests a weak protoclastic texture.

Map Reference No. 112
Sample No. KR31-74

Nepheline-bearing, amphibole syenite.

Field Description. Coarse grained, equigranular. Weathered surfaces are pink to buff, fresh surfaces buff. Map Unit 6d.

Petrographic Description. Coarse grained, equigranular, massive, allotriomorphic, with curved to straight grain boundaries. Dark brown to green-brown amphibole contains some poikilitic apatite. Pyroxene is relict and thickly mantled with amphibole. Nepheline is intensely stained, highly altered, and interstitial. Biotite occurs associated with the amphibole. Some plagioclase may have formed as exsolution (?) of perthite and is present as discrete weakly twinned grains. Twinning is very diffuse and minor disruptions in twin planes suggests a protoclastic texture. Patch perthite occurs as irregular grains enclosing some irregular, angular crystals and crystal fragments of plagioclase in random orientation.

Map Reference No. 113
Sample No. KR31-84

Amphibole syenite.

Field Description. Coarse grained, equigranular, massive, weakly trachytoidal. Weathered surfaces are pink to buff, fresh surfaces pink-brown. Map Unit 6e.

Petrographic Description. Coarse grained, equigranular, massive, allotriomorphic with straight to curved grain boundaries. Olivine occurs as rounded grains altered to iddingsite and rarely chlorite. Magnetite is common after olivine. Plagioclase (An32) forms anhedral mosaics of crystals separated by perthitic feldspar. Plagioclase has bent twin lamallae and fractures and thus displays a protoclastic texture. Sericite alteration occurs along the fractures. Patch perthite forms irregular grains interstitial to plagioclase and surrounds plagioclase crystal mosaics and crystal fragments. Amphibole is dark brown to green-brown and interstitial to the feldspars.

Map Reference No. 114
Sample No. KR33-20

Biotite, amphibole, nepheline syenite.

Field Description. Coarse grained, massive, equigranular. Weathered and fresh surfaces are buff in colour. Map Unit 6d.

Petrographic Description. Medium to coarse grained, massive, equigranular, allotriomorphic, with straight to curved grain boundaries. Nepheline is intensely stained and encloses some plagioclase grains. Nepheline forms irregular patchy areas. Pyroxene occurs as relicts mantled by amphibole. Amphibole is dark brown to green-brown and interstitial. Apatite is poikilitic in the amphibole and pyroxene. Plagioclase forms anhedral tabular mosaics partially enclosed by perthite. Perthite is interstitial to plagioclase and is both patchy and stringy; grains are irregular in outline.

Map Reference No. 115
Sample No. K2D-24B

Amphibole syenite.

Field Description. Medium grained, equigranular, massive, with acicular mafic mineral. Pitted weathered surfaces are grey; fresh surfaces are grey-green. Map Unit 6j.

Petrographic Description. Fine to medium grained, equigranular, massive, allotriomorphic to hypidiomorphic, with curved to straight grain boundaries. Feldspar is antiperthite and staining indicates irregular patchy distribution of potassium. Amphibole crystals are zoned from green-brown cores to dark green rims and have crudely anhedral outlines in cross-section.

Map Reference No. 116
Sample No. K2D-68A

Amphibole, cancrinite syenite.

Field Description. Medium grained to pegmatitic. Rock is xenolithic with inclusions up to 40 by 40 cm. Xenoliths are subangular and composed of syenite. Outcrop is streaky and has a crude banding. Weak trachytoidal texture is present in the feldspars. Sample was taken from medium-grained, equigranular, homogeneous area of outcrop. Weathered surfaces are light grey to buff, fresh surfaces grey. Map Unit 6n.

Petrographic Description. Medium grained, equigranular, massive, allotriomorphic, with curved to embayed grain boundaries. Orthoclase feldspar show Carlsbad twinning. Cancrinite forms large continuous grains completely enclosing the feldspar and amphibole. The amphibole has dark green-brown cores with green rims. Amphibole looks worm eaten and corroded. Traces of garnet and calcite are present.

Map Reference No. 117
Sample No. K15X-36

Pyroxene, amphibole syenite.

Field Description. Medium grained, equigranular, massive. Weathered surfaces are white, fresh surfaces pink-white. Map Unit 6d.

Petrographic Description. Coarse grained, massive, equigranular, allotriomorphic, with embayed grain boundaries. Brown amphibole rims pyroxene interstitial to feldspar. Apatite is poikilitic in amphibole and pyroxene. Feldspar is a patch perthite.

Map Reference No. 118
Sample No. K15X-44

Troctolite.

Field Description. Medium grained, equigranular, massive. Weathered surfaces are brown, fresh surfaces brown to blue-grey. Map Unit 4b.

Petrographic Description. Fine grained, massive, equigranular, allotriomorphic, with curved grain boundaries. Irregular fresh olivine grains contain bead-like plagioclase inclusions. One olivine grain contains pyroxene with a weak schiller and minor actinolite (?). Plagioclase forms an interlocking mosaic of anhedral grains.

Map Reference No. 119
Sample No. K25X-6B

Amphibole syenite.

Field Description. Coarse grained, massive, equigranular. Trachytoidal structure on outcrop. Weathered surfaces are pink-white, fresh surfaces pale pink. Map Unit 6h.

Petrographic Description. Coarse grained, equigranular, massive, allotriomorphic, with straight to curved grain boundaries. Dark brown interstitial amphibole rims relict pyroxene; one olivine grain within amphibole displays alteration to magnetite. Plagioclase occurs as an anhedral interstitial mosaic between larger perthite grains. Some plagioclase is partially replaced by perthite. Plagioclase is fractured or protoclastic and sericite is present along cracks. Perthite forms irregular grains with typical patch perthite pattern.

Map Reference No. 120
Sample No. K25X-40

Amphibole syenite.

Field Description. Medium grained, equigranular, massive. Weathered and fresh surfaces are white to buff. Traces of nepheline are possibly present. Map Unit 6h.

Petrographic Description. Coarse grained, massive, equigranular, allotriomorphic, with straight and curved boundaries. Dark brown interstitial amphibole contains occasional, poikilitic apatite inclusions. Pyroxene occurs as a relict thickly mantled with amphibole. Trace amounts of highly altered nepheline are present. Plagioclase forms anhedral grains interstitial to the perthite, and also occurs as inclusions in perthite. Fractures show incipient sericite alteration. Perthite is patchy and encloses an occasional grain of plagioclase at random orientation.

Map Reference No. 121
Sample No. K26X-50B

Olivine gabbro.

Field Description. Medium grained, massive, equigranular. Weathered surface and fresh surfaces are grey-black. Map Unit 4a.

Petrographic Description. Medium grained, equigranular, massive, hypidiomorphic. Olivine forms rounded grains enclosed or partially enclosed in pyroxene. Dark brown alteration of grains along fractures may be iddingsite. Pyroxene is clearly interstitial and has plagioclase crystals projecting into it. Plagioclase (An60) forms an interlocking mosaic of tabular crystals with anhedral crystal faces projecting into the pyroxene. Biotite is interstitial, most commonly associated with magnetite.

Map Reference No. 122
Sample No. K26X-55

Amphibole, nepheline syenite.

Field Description. Coarse grained, equigranular, massive. Gabbro occurs as large blocks (30 volume percent) in syenite. Weathered surfaces are buff, fresh surfaces pinkish. Map Unit 6h.

Petrographic Description. Medium grained, equigranular, massive, allotriomorphic, with straight to curved grain boundaries. Nepheline is highly altered and interstitial to other minerals. Amphibole is green to brown-green, in part, possibly after pyroxene. Disseminated irregular magnetite grains commonly have very narrow rims of biotite. Feldspar is perthitic and displays intense patchy staining; crystals are tabular with potassium staining more intense along grain margins. There is no evidence of albite twinning on any feldspar grains.

Map Reference No. 123
Sample No. K26X-96

Olivine gabbro.

Field Description. Medium grained, equigranular. Weathered surfaces are brown, fresh surfaces blue-grey. Map Unit 4a.

Petrographic Description. Medium grained, equigranular, massive, allotriomorphic, with straight to curved grain boundaries. Magnetite occurs as irregular anastomosing disseminated grains commonly rimmed with biotite. Olivine forms irregular generally fresh grains, but commonly with magnetite along periphery and interior to grain. Pyroxene is interstitial to plagioclase. Pyroxene forms irregular grains. Plagioclase (An 44) forms an interlocking mosaic of crystals.

Map Reference No. 124
Sample No. K31X-49

Olivine gabbro.

Field Description. Medium grained, equigranular, massive. Weathered surfaces are black to rusty brown, fresh surfaces green-black. Map Unit 4a.

Petrographic Description. Medium grained, equigranular, massive, hypidiomorphic, subophitic. Olivine forms irregular interstitial grains locally altered to dark red-brown iddingsite. Pyroxene contains an occasional feldspar crystal and one grain contains an olivine grain. Pyroxene is interstitial. Plagioclase (An60) forms an interlocking mosaic of tabular crystals. Biotite and brown-green amphibole occur as minor alterations of the other mafic minerals. Magnetite is interstitial.

Map Reference No. 125
Sample No. K32X-7

Nepheline, amphibole syenite.

Field Description. Medium grained, equigranular, massive. Weathered surfaces are grey, fresh surfaces pink-white. Map Unit 6h.

Petrographic Description. Coarse grained, equigranular, allotriomorphic, with straight to curved grain boundaries. Nepheline is interstitial to everything and shows moderate alteration along rim of grain. Subangular plagioclase inclusions occur along margins of nepheline grains. Pyroxene occurs as relict cores thickly mantled with amphibole. Magnetite grains occur within the amphibole, presumably resulting from the alteration of the pyroxene. Plagioclase (An32) occurs as anhedral grains. Perthite is patchy and locally stringy. Perthite encloses subangular to angular grains and crystal fragments of plagioclase.

Map Reference No. 126
Sample No. K32X-14B

Pyroxene, amphibole, nepheline syenite.

Field Description. Coarse grained, massive, equigranular. Weak schiller was noted on feldspars. Weathered and fresh surfaces are pink-grey. Map Unit 6h.

Petrographic Description. Medium grained, equigranular, massive, allotriomorphic, with straight to curved grain boundaries. Nepheline is intensely stained, interstitial and altered. Pyroxene occurs as amphibole mantled relicts. Perthite is a string perthite, very fine grained, consisting of an interlocking mosaic of grains. No albite twinning was observed. Staining for potassium is concentrated along grain boundaries and fractures.

Map Reference No. 127
Sample No. K34X-1B

Olivine gabbro.

Field Description. Medium grained, massive, equigranular. Weathered surfaces are grey-black, fresh surfaces green-black. Map Unit 4a.

Petrographic Description. Medium grained, equigranular, allotriomorphic, with curved to straight grain boundaries. Magnetite forms irregular cuspate grains possibly after olivine and pyroxene. Biotite occurs in trace amounts along margins of pyroxene and amphibole and rims magnetite after olivine. Pyroxene is interstitial to plagioclase and has well developed reaction rims. Olivine occurs as subrounded grains in close association with pyroxene. Locally olivine is completely altered to biotite and magnetite. Plagioclase (An57) forms anhedral interlocking mosaics of crystals. Olivine and pyroxene have well developed myrmekitic rims of fine grained amphibole and untwinned plagioclase.

Map Reference No. 128
Sample No. K34X-12

Olivine gabbro.

Field Description. Medium grained, equigranular, massive. Weathered surfaces are brown, fresh surfaces grey-black. Map Unt 4b.

Petrographic Description. Medium grained, equigranular, massive, allotriomorphic, with curved to straight grain boundaries. Biotite rims magnetite after olivine. Olivine occurs as rounded to subrounded irregular grains locally extensively altered to dark brown iddingsite. Magnetite locally forms irregular cuspate interstitial grains, some with biotite along edges. Pyroxene is interstitial and encloses both olivine and plagioclase. Plagioclase (An69) forms an interlocking anhedral mosaic. Local bending of plagioclase twin planes suggests some protoclastic texture.

Map Reference No. 129
Sample No. K34X-22

Gabbro.

Field Description. Very fine grained, equigranular, massive. Weathered surfaces are tan, fresh surfaces black. Map Unit 4d.

Petrographic Description. Fine grained, equigranular, allotriomorphic, with curved to straight grain boundaries. Magnetite forms irregular subrounded grains. Plagioclase (An58) forms anhedral, crudely tabular crystals in an interlocking mosaic. Pyroxene forms subrounded irregular grains between the plagioclase crystals.

Map Reference No. 130
Sample No. K34X-42B

Olivine gabbro.

Field Description. Medium grained, equigranular, massive. Weathered and fresh surfaces are black. Map Unit 4a.

Petrographic Description. Medium grained, equigranular, massive, allotriomorphic, with curved to straight grain boundaries. Biotite is commonly associated with magnetite, perhaps after olivine. Olivine forms irregular rounded grains between plagioclase; it is commonly associated with pyroxene. Pyroxene forms rounded interstitial grains enveloped in myrmekite. Plagioclase forms an interlocking mosaic of anhedral crystals. Myrmekite rims olivine and pyroxene, and consists of parallel acicular light green amphiboles and untwinned plagioclase intergrowths normal to the grain boundaries.

Map Reference No. 131
Sample No. K34X-49

Olivine gabbro.

Field Description. Medium grained, equigranular, massive. Weathered surfaces are mottled grey-black, fresh surfaces green-black. Map Unit 4a.

Petrographic Description. Medium grained, equigranular, massive, allotriomorphic, with curved to straight grain boundaries. Magnetite occurs along grain boundaries, between pyroxene grains, within pyroxene and as alteration of olivine. Plagioclase (An62) forms an anhedral interlocking mosaic. Some crystals have bent twin planes and are thus protoclastic. Pyroxene is interstitial and displays a schiller texture. Olivine forms rounded irregular grains associated with the pyroxene and between the plagioclase grains. Magnetite and biotite alteration occurs along rim of olivine grains.

Map Reference No. 132
Sample No. KR25-29

Biotite, amphibole syenite.

Field Description. Coarse grained, massive, equigranular. Outcrop has well developed mafic segregation banding. Amphibole is subophitic with respect to feldspars. Sample was taken from homogeneous area of exposure. Weathered and fresh surfaces are buff in colour. Map Unit 6d.

Petrographic Description. Coarse grained, massive, equigranular, allotriomorphic, with straight to curved grain boundaries. Biotite occurs as isolated booklets and in association with amphibole. Amphibole is dark green-brown and interstitial to the feldspars. Plagioclase occurs as inclusions in perthite and as untwinned anhedral interstitial grains. Perthite occurs as large grains of patch perthite with some inclusions in a random pattern of plagioclase crystals and crystal fragments.

Map Reference No. 133
Sample No. KR31-6

Pyroxene, biotite, amphibole syenite.

Field Description. Coarse grained, equigranular, massive. Mafic minerals are subophitic with respect to feldspar. Colour index is 15-20. Weathered and fresh surfaces are buff. Map Unit 6d.

Petrographic Description. Medium to coarse grained, massive, equigranular, allotriomorphic, with curved grain boundaries. Pyroxene forms pale green grains thickly mantled with amphibole. Biotite forms anhedral books interlocking with amphibole. Amphibole is anhedral and interstitial; larger grains have unaltered pyroxene cores. Amphibole is dark green to brown. Apatite forms euhedral grains poikilitic in mafics. Plagioclase forms anhedral grains interlocking with perthite. Perthite is patchy, in part replacing plagioclase. Larger perthite grains contain anhedral grains of plagioclase.

Map Reference No. 134
Sample No. KR18-34

Amphibole syenite.

Field Description. Coarse grained, massive. equigranular. Mafic minerals are in subophitic arrangement with feldspars. Colour index is 15 to 20. Weathered and fresh surfaces are buff. Map Unit 6d.

Petrographic Description. Medium to coarse grained, massive, equigranular, hypidiomorphic. Biotite forms ragged grains in association with amphibole and in part replaces amphibole. Amphibole forms anhedral, irregular interstitial dark green to brown grains. Plagioclase forms euhedral to subhedral grains which may have bent and offset twin lamellae. Perthite forms large irregular grains with stringy texture, in part engulfing and partially enclosing the plagioclase. Trace to minor amounts of magnetite, cancrinite, nepheline, pyroxene and apatite are present.

Map Reference No. 135
Sample No. KR7-62

Nepheline-bearing, amphibole syenite.

Field Description. Coarse grained, massive, equigranular. Mafic minerals have a subophitic relation with feldspars. Subparallel orientation of tabular feldspars gives a trachytoidal texture to rock. Weathered and fresh surfaces are buff. Map Unit 6h.

Petrographic Description. Medium to coarse grained, massive, equigranular, hypidiomorphic. Amphibole forms dark green to brown anhedral grains, interstitial to subophitic with potassium feldspar. Traces of brown biotite occur between amphibole grains. Traces of pyroxene occur as small bead-like grains thickly mantled with amphibole. Feldspar is perthitic, dominantly a patch perthite but also minor string perthite. Grains are subhedral to anhedral in form. Irregular albite replacements (?) have albite twin planes parallel to long axis of grains. Feldspar grains form an interlocking mosaic. Nepheline is interstitial to feldspar and is undergoing alteration to cancrinite (?).

Map Reference No. 136
Sample No. KR22-55

Amphibole syenite.

Field Description. Coarse grained, massive, equigranular. Colour index is 15 to 20. Fresh surfaces are pale pink to yellowish buff, weathered surfaces pale brown. Map Unit 6d.

Petrographic Description. Medium to coarse grained, massive, equigranular, hypidiomorphic. Amphibole is dark brown to green, anhedral, and interstitial. Biotite forms brown, ragged, irregular grains interstitial with and replacing amphibole. Plagioclase forms anhedral to subhedral grains partially enclosed in large perthite grains. Bent and distorted albite twin planes imply a protoclastic texture. Perthite forms an interlocking mosaic and occurs as both stringy and patchy types; patch perthite dominates.

Map Reference No. 137
Sample No. KR23-246A

Biotite, amphibole syenite.

Field Description. Coarse grained, massive, equigranular. Weathered and fresh surfaces are pinkish buff. Colour index is 15 to 20. Map Unit 6e.

Petrographic Description. Medium to coarse grained, equigranular, massive, hypidiomorphic. Amphibole forms dark green to brown anhedral interstitial grains. Minor irregular grains of pyroxene occur in cores of larger amphibole grains. Traces of very dark brown garnet are present. Traces of disseminated magnetite are associated with mafic minerals. Biotite forms brown anhedral grains commonly associated with the amphibole. Apatite forms small crystals poikilitic in garnet and other mafic minerals. Plagioclase (An13) forms subhedral to euhedral grains. Larger grains have bent twin lamellae and define a protoclastic texture. Perthite is stringy and forms large amoeboid grains which partially to completely enclose plagioclase.

Map Reference No. 138
Sample No. KR33-2

Amphibole syenite.

Field Description. Coarse grained, massive, equigranular. Weathered and fresh surfaces are buff. Mafic minerals are in a subophitic arrangement with feldspars. Colour index is approximately 15. Map Unit 6d.

Petrographic Description. Medium to coarse grained, massive, inequigranular-seriate, hypidiomorphic. Amphibole is dark brown to green, anhedral and interstitial. Traces of disseminated magnetite occur within amphibole. Minor euhedral apatite is poikilitic in mafic minerals. Biotite forms dark brown grains interstitial to feldspar and mafics; in part it replaces amphibole. Perthite is an antiperthite with patches of potassium feldspar separated by screens of twinned plagioclase. Plagioclase is albitic forming subhedral to anhedral grains, rarely with a weak protoclastic texture.

Map Reference No. 139
Sample No. KR23-47

Amphibole syenite.

Field Description. Coarse grained, massive, equigranular. Weathered and fresh surfaces are red-brown. Colour index is approximately 15 to 20. Map Unit 6e.

Petrographic Description. Medium to coarse grained, massive, equigranular, hypidiomorphic. Minor brown biotite forms irregular ragged grains in association with amphibole. Amphibole is dark brown to green, anhedral and interstitial. Plagioclase forms anhedral to subhedral grains and irregular patches in patch perthite. Perthite forms anhedral grains completely enclosing some of the smaller plagioclase grains and locally replacing the plagiocase. Trace to minor amounts of pyroxene, magnetite and apatite are present.

Map Reference No. 140
Sample No. KR33-5

Pyroxene, amphibole syenite.

Field Description. Medium to coarse grained. Colour index is approximately 15 to 20. Weathered and fresh surfaces are buff. Map Unit 6d.

Petrographic Description. Medium to coarse grained, massive, equigranular, hypidiomorphic. Pyroxene is pale green with thick mantles of amphibole. Amphibole replaces the pyroxene. Amphibole is dark green to brown, anhedral, and interstitial. Minor brown biotite in part replaces amphibole. Plagioclase forms anhedral grains interlocking with perthite. Perthite is patchy, possibly in part replacing plagioclase; grains are anhedral and interlocking

Map Reference No. 141
Sample No. KR16-46

Amphibole, pyroxene syenite.

Field Description. Medium to coarse grained, massive, equigranular. Weathered and fresh surfaces are pink-brown. Colour index is 15 to 20. Map Unit 6e.

Petrographic Description. Medium to coarse grained, massive, equigranular, allotriomorphic, with serrate grain boundaries. Amphibole forms dark green to brown rims on the pyroxene. Pyroxene is pale green, forms anhedral irregular grains and is invariably altered along its rims. Minor magnetite and biotite occur in association with pyroxene and may be the result of alteration of the pyroxene. Perthite is patchy, forming anhedral grains which have serrated interlocking boundaries.

Map Reference No. 142
Sample No. KR23-181

Amphibole syenite.

Field Description. Coarse grained, massive, equigranular. Colour index is about 15. Weathered and fresh surfaces are pink-brown. Map Unit 6e.

Petrographic Description. Medium to coarse grained, equigranular, hypidiomorphic. Plagioclase (An6-8) forms anhedral to subhedral, interlocking, irregular grains with bent twin lamellae and minor dislocations. Plagioclase is protoclastic. Perthite forms anhedral irregular grains interlocking with plagioclase. Perthite is patchy; locally some stringy perthite is present. Very minor euhedral apatite is present. Amphibole is anhedral, interstitial and dark green to brown in colour. Several grains of olivine are completely altered.

Map Reference No. 143
Sample No. KR16-26

Biotite, amphibole syenite.

Field Description. Medium to coarse grained, equigranular, massive. Colour index is 20 to 25. Fresh and weathered surfaces are brown. Map Unit 6j.

Petrographic Description. Medium to coarse grained, equigranular, allotriomorphic, with curved to serrate grain boundaries. Biotite forms brown anhedral grains interlocking with amphibole. Amphibole forms dark brown to green anhedral interstitial grains. Apatite forms euhedral grains poikilitic in mafic minerals. Myrmekite forms irregular grains with prominent vermicular exsolution features. Myrmekite probably consists of two feldspars. Plagioclase forms irregular anhedral grains, generally small relative to the perthite. Stringy perthite forms irregular anhedral grains with serrate grain boundaries. Larger grains contain small euhedral plagioclase grains.

Map Reference No. 144
Sample No. KR23-158

Biotite amphibole syenite.

Field Description. Medium to coarse grained, equigranular, massive. Mafic minerals have a subophitic relationship with feldspar. Weathered and fresh surfaces are buff to pale pink. Map Unit 6d.

Petrographic Description. Medium to coarse grained, equigranular, allotriomorphic, with curved to lobate grain boundaries. Amphibole forms dark green to brown anhedral grains, interstitial to the feldspars. Biotite forms anhedral irregular grains interlocking with amphibole. Plagioclase forms anhedral irregular grains in part enclosed in perthite. Perthite forms irregular grains which have interlocking grain boundaries and may completely enclose the plagioclase.

Map Reference No. 145
Sample No. KR22-192

Amphibole syenite.

Field Description. Coarse grained, massive, equigranular. Mafic minerals are subophitic in relation to feldspars. Weathered and fresh surfaces are buff. Colour index is approximately 15. Map Unit 6d.

Petrographic Description. Medium to coarse grained, massive, equigranular, hypidiomorphic. Amphibole forms dark green to brown anhedral interstitial grains. Amphibole is in subophitic arrangements with some of the plagioclase. Minor biotite occurs along flanks of amphibole grains. Plagioclase (An10-11) forms anhedral to euhedral grains, some with bent twin lamellae and minor dislocations. Plagioclase is protoclastic. Perthite forms anhedral irregular grains, dominantly patchy, with some subordinate stringy perthite. Some of the larger perthite grains contain subhedral grains of plagioclase.

Map Reference No. 146
Sample No. KR23-50

Amphibole, pyroxene syenite.

Field Description. Medium to coarse grained, massive, equigranular with weak trachytoidal texture. Colour index is approximately 15. Weathered and fresh surfaces are red-brown. Map Unit 6e.

Petrographic Description. Medium to coarse grained, equigranular, allotriomorphic, with straight to interdigitating grain boundaries. Minor magnetite forms round blebs in association with pyroxene. Magnetite may be in part an alteration of the pyroxene. Pyroxene is a pale green aegirine-augite thinly mantled with amphibole. Amphibole is dark green to brown and commonly mantles pyroxene. Plagioclase forms anhedral to subhedral crystals interlocking with perthite and possibly orthoclase. Perthite is patchy, forming anhedral grains interlocking with plagioclase and possibly orthoclase.

Map Reference No. 147
Sample No. KR16-6

Pyroxene monzonite to syenite.

Field Description. Coarse grained, massive, equigranular. Colour index is 5-10. Weathered and fresh surfaces are dark red-brown. Map Unit 6g.

Petrographic Description. Medium to coarse grained, massive, allotriomorphic, with curved to straight grain boundaries. Pyroxene forms rounded to subhedral grains of pale green colour. Extinction angle suggests augite. Minor magnetite occurs as small disseminated grains in association with pyroxene and amphibole. In part the magnetite may result from alteration of the pyroxene. Amphibole is dark green to brown and rims pyroxene. Plagioclase (An8-12?) forms anhedral to subhedral grains. Larger grains display bent twin lamillae and minor dislocations indicative of a protoclastic texture. Perthite forms anhedral grains with a stringy perthite texture visible at high magnification. Minor brown anhedral biotite is associated with other mafic minerals. Traces of olivine are largely altered to iddingsite (?).

Map Reference No. 148
Sample No. KR18-78

Amphibole, pyroxene syenite.

Field Description. Medium to coarse grained, massive, equigranular. Colour index is 15-20. Weathered and fresh surfaces are buff. Map Unit 6d.

Petrographic Description. Medium to coarse grained, massive, equigranular, allotriomorphic, with curved to straight grain boundaries. Pyroxene is a pale green anhedral aegirine-augite, mantled with amphibole. Amphibole is dark green to brown, interstitial to feldspar or mantling pyroxene. Perthite forms two types: patch perthite which is in part a replacement of plagioclase, and string perthite. The string perthite forms large anhedral grains, in part enclosing small grains of turbid plagioclase. No fresh plagioclase remains. Plagioclase is of albitic composition. Grains of patch perthite are commonly antiperthitic.

Map Reference No. 149
Sample No. KR23-260

Monzonite.

Field Description. Fine to coarse grained, massive, inequigranular to porphyritic-seriate. Phenocrysts up to 1 cm have seriate distribution and comprise approximately 5% of rock. Weathered surfaces are pink-grey, fresh surfaces dark pink-grey. Map Unit 5a.

Petrographic Description. Medium grained, massive, equigranular, hypidiomorphic. Olivine forms small bead-like grains in association with pyroxene and amphibole. Pyroxene is a pale green augite, anhedral, and commonly mantled with amphibole. Amphibole is dark green to brown in colour and occurs as interstitial grains and mantles to the pyroxene. Magnetite forms anhedral disseminated grains commonly poikilitic in amphibole. Potassium feldspar is a Carlsbad-twinned orthoclase displaying a weak subparallel orientation. Crystals are anhedral to subhedral. Perthite forms isolated anhedral grains of patch perthite, which tends to be antiperthite.

Map Reference No. 150
Sample No. KR33-9

Nepheline-bearing monzonite.

Field Description. Medium grained, massive, equigranular. Colour index is about 20. Weathered and fresh surfaces are pink-grey. Map Unit 5a.

Petrographic Description. Fine to medium grained, equigranular, hypidiomorphic. Nepheline forms rounded blebs and euhedral blocky crystals. It is poikilitic in orthoclase and occurs as interstitial anhedral grains. Orthoclase is anhedral to euhedral and displays a wavy extinction suggestive of incipient development of perthite. Amphibole occurs as dark green to brown anhedral grains interstitial to the feldspars. Olivine occurs as small bead-like grains interstitial to amphibole. Pyroxene occurs in trace amounts as relicts in cores of larger amphibole grains. Minor magnetite is associated with other mafics, in part, resulting from the alteration of the pyroxene and olivine.

Map Reference No. 151
Sample No. KR33-17

Nepheline-bearing monzonite.

Field Description. Medium grained, massive, equigranular. The rock is weakly trachytoidal due to subparallel orientation of tabular feldspars. Colour index is approximately 20. Weathered and fresh surfaces are pink-grey. Weathered surface suggests presence of nepheline. Map Unit 6h.

Petrographic Description. Fine to medium grained, massive, hypidiomorphic. Olivine forms irregular bead-like grains. Pyroxene forms anhedral grains mantled with amphibole and partially enclosing olivine. Magnetite forms rounded irregular grains in association with other mafic minerals. Nepheline forms rounded to euhedral grains poikilitic in tabular orthoclase crystals and as isolated, anhedral, interstitial grains. Orthoclase occurs as anhedral to euhedral, tabular, Carlsbad- twinned grains which often display a wavy extinction, possibly indicating perthitic development.

Map Reference No. 151A
Sample No. KR21-183

Nepheline-, pyroxene-, biotite-bearing, amphibole syenite.

Field Description. Medium to coarse grained, massive. Amphibole occurs as oikocrystic grains up to 2 cm in diameter, enveloping feldspars. Weathered surfaces are buff, fresh surfaces pale pink to buff. Map Unit 6d.

Petrographic Description. Fine to medium grained, massive, inequigranular-seriate, allotriomorphic, with curved to lobate grain boundaries. Apatite is present as small euhedral prismatic crystals poikilitic in amphibole. Amphibole is anhedral, dark brown, interstitial to and enclosing feldspar; it may poikilitically enclose magnetite, biotite and apatite. Biotite occurs in minor amounts as tabular brown anhedral grains commonly enclosed in amphibole. Magnetite occurs as minor anhedral disseminated grains, generally poikilitic in amphibole. Traces of zircon form very tiny poikilitic grains in biotite with radioactivity bombardment halos. Minor nepheline is present as anhedral interstitial grains commonly altering to cancrinite. Clinopyroxene is present as anhedral grains thickly mantled with dark brown amphibole. Clinopyroxene is likely breaking down to amphibole. Feldspar is a perthite consisting of interlocking grains, commonly displaying an antiperthitic patch perthite texture. Albite twinning is common as faint vestiges. Carlsbad twinning is present in some grains. Traces of dark brown anhedral garnet are present.

Map Reference No. 1153
Sample No. K33X-32

Biotite-bearing, amphibole, pyroxene, nepheline syenite.

Field Description. Medium to coarse grained, massive, weakly trachytoid. Weathered and fresh surfaces are pitted from weathering of nepheline. Pits are up to 3-5 mm in diameter and 2-3 mm deep. Map Unit 6h.

Petrographic Description. Fine to medium grained, massive, inequigranular-seriate, allotriomorphic, with curved to straight grain boundaries. Perthite is dominantly an anhedral string perthite with occasional Carlsbad twinning. Minor patch perthite (An10-14) consists of plagioclase with patchy potassium feldspar replacement. Patch perthite is an antiperthite. Nepheline is anhedral, irregular to blocky, and interstitial, with turbid alteration along margins and parallel to "C" crystallographic axis. Clinopyroxene is anhedral, interlocking with perthite, green to pale green in colour. The pyroxene cores are slightly paler in colour than the rims and are likely a sodic variety. Clinopyroxene is rimmed with amphibole. Amphibole forms green to green-brown rims on clinopyroxene and also occurs as isolated interstitial grains. Biotite forms anhedral red-brown interstitial grains.

Map Reference No. 1154
Sample No. KR23-226

Biotite, amphibole syenite.

Field Description. Medium to coarse grained, massive. Weathered and fresh surfaces are buff coloured. Amphiboles are interstitial to other amphiboles. Map Unit 6e.

Petrographic Description. Fine to medium grained, massive, inequigranular-seriate, allotriomorphic, with curved to straight grain boundaries. Plagioclase locally appears fragmented and is enclosed in perthite and amphibole. Perthite is anhedral, interstitial, and has well developed stringy texture. Perthite locally encloses fragments of plagioclase. Amphibole is dark green-brown, interstitial to perthite and may contain poikilitic plagioclase. The largest grain contains ragged relicts of greenish clinopyroxene. Biotite forms tabular anhedral brown grains interstitial to perthite. Grains are irregular in form where interstitial, and more tabular where marginal to amphibole.

TABLE A-2. MAJOR ELEMENT ANALYSES (WEIGHT PERCENT) OF WHOLE-ROCK SAMPLES FROM THE KILLALA LAKE ALKALIC ROCK COMPLEX.

	Gabbro						
Ref. No.	69	70	74	75	76	77	98
SiO_2	47.9	41.7	47.4	47.8	47.4	46.1	51.1
Al_2O_3	25.4	17.2	14.4	25.3	19.5	24.9	14.7
Fe_2O_3	1.54	12.9	11.1	1.66	1.49	2.13	3.73
FeO	2.17	3.57	2.80	3.01	5.67	3.15	8.25
MgO	3.83	7.71	6.70	2.67	7.51	3.88	5.99
CaO	14.3	10.8	11.5	12.9	13.4	15.2	10.1
Na_2O	3.54	3.23	7.80	3.98	3.18	2.66	3.78
K_2O	0.60	0.34	0.48	0.60	0.43	0.35	0.40
TiO_2	0.12	1.31	1.27	0.36	0.37	0.27	1.31
P_2O_5	0.10	1.10	0.15	0.46	0.43	0.25	0.19
S	<0.1	0.09	<0.01	0.02	0.02	<0.01	<0.01
MnO	0.07	0.21	0.20	0.07	0.13	0.11	0.17
CO_2	0.23	0.22	0.11	0.18	0.19	0.17	0.28
H_2O+	0.29	0.16	0.29	0.25	0.26	0.40	0.03
H_2O-	0.39	0.36	0.39	0.41	0.39	0.30	0.43
Total	100.50	100.90	100.60	99.70	100.40	99.90	100.50

	Gabbro						
Ref. No.	99	100	101	102	103	106	118
SiO_2	45.9	46.0	47.7	47.9	48.4	40.3	45.7
Al_2O_3	19.7	20.5	25.0	24.1	20.7	10.3	19.5
Fe_2O_3	3.33	3.09	1.74	1.82	1.48	6.31	1.35
FeO	7.35	6.58	3.43	3.08	3.71	12.68	8.33
MgO	6.80	4.70	3.66	3.43	6.17	10.8	10.2
CaO	11.1	12.6	13.7	13.9	15.2	13.6	10.2
Na_2O	2.94	3.88	2.89	3.46	2.56	1.43	2.43
K_2O	0.52	0.39	0.35	0.65	0.42	0.19	0.39
TiO_2	0.69	0.89	0.28	0.31	0.25	1.39	0.34
P_2O_5	0.36	0.72	0.17	0.23	0.22	1.20	0.44
S	0.06	0.04	<0.01	0.01	<0.01	0.02	0.05
MnO	0.14	0.12	0.07	0.08	0.08	0.21	0.14
CO_2	0.38	0.35	0.15	0.30	0.19	0.15	0.41
H_2O+	0.37	0.16	0.35	0.40	0.39	0.28	0.35
H_2O-	0.52	0.47	0.42	0.41	0.52	0.34	0.40
Total	100.20	100.50	99.90	100.10	100.30	99.20	100.20

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
69	KR 21-50	99	KR 25-9
70	KR 21-73	100	KR 25-12
74	KR 21-159	101	KR 25-19
75	KR 21-162	102	KR 25-20B
76	KR 21-169B	103	KR 25-36
77	KR 21-171	106	KR 28-35
98	KR 25-5	118	K15X-44

TABLE A-2. CONTINUED.

	Gabbro						
Ref. No.	**121**	**123**	**124**	**127**	**129**	**130**	**128**
SiO_2	45.1	47.6	48.4	43.9	45.2	44.6	47.2
Al_2O_3	19.1	20.0	19.7	16.5	14.5	16.1	20.4
Fe_2O_3	3.81	4.20	1.85	3.30	3.66	3.43	1.98
FeO	7.28	6.30	5.81	9.10	8.95	8.25	6.94
MgO	5.68	3.85	7.21	6.78	8.21	6.43	7.18
CaO	12.1	9.94	12.7	12.7	13.5	12.9	10.4
Na_2O	2.87	3.83	2.58	3.04	2.38	4.30	3.02
K_2O	0.44	0.54	0.37	0.40	0.24	1.03	0.38
TiO_2	1.00	1.33	0.47	0.93	0.76	0.87	0.50
P_2O_5	0.79	0.50	0.37	1.10	0.81	0.80	0.37
S	0.10	<0.01	0.04	0.05	0.06	<0.01	0.03
MnO	0.13	0.12	0.11	0.16	0.20	0.15	0.13
CO_2	0.26	0.21	0.19	0.16	0.23	0.22	0.66
H_2O+	0.53	0.33	0.38	0.18	0.39	0.28	0.13
H_2O-	0.43	0.53	0.50	0.39	0.37	0.28	0.42
Total	99.60	99.30	100.70	98.70	99.50	99.60	99.70

	Gabbro	Larvikite			Monzonite		
Ref. No.	**131**	**71**	**104**	**107**	**149**	**150**	**85**
SiO_2	45.7	55.7	56.9	54.2	53.7	55.9	54.0
Al_2O_3	15.8	11.0	15.7	15.5	17.4	20.4	17.3
Fe_2O_3	4.00	7.99	2.82	5.70	2.08	2.07	2.47
FeO	9.31	2.80	7.27	6.30	6.92	3.22	6.37
MgO	6.90	1.21	1.03	1.28	2.04	0.30	2.21
CaO	12.5	4.78	4.04	4.64	4.98	1.99	5.10
Na_2O	2.52	5.19	5.53	4.93	4.82	7.63	5.17
K_2O	0.37	4.07	4.13	3.77	4.83	6.11	4.94
TiO_2	1.38	1.31	1.17	1.76	0.83	0.31	0.84
P_2O_5	0.12	0.43	0.40	0.48	0.49	0.13	0.50
S	0.01	0.06	0.05	0.05	0.04	<0.01	0.03
MnO	0.14	0.24	0.24	0.24	0.24	0.17	0.22
CO_2	0.15	0.21	0.19	0.32	0.30	0.26	0.15
H_2O+	0.00	0.47	0.10	0.06	0.12	0.05	0.07
H_2O-	0.32	0.41	0.44	0.41	0.36	0.28	0.44
Total	99.20	100.40	100.00	99.60	99.20	98.80	99.80

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
121	K26X-50B	131	K34X-49
123	K26X-96	71	KR 21-92
124	K31X-49	104	KR 28-23
127	K34X-1B	107	KR 28-42
129	K34X-22	149	KR 23-260
130	K34X-42B	150	KR 33-9
128	K34X-12	85	KR 23-3B

TABLE A-2. CONTINUED.

	Monzonite					Buff Syenite	
Ref. No.	86	89	90	93	95	134	148
SiO_2	53.3	53.9	54.4	53.8	54.2	57.9	57.4
Al_2O_3	17.9	17.0	17.1	17.0	17.0	19.5	18.8
Fe_2O_3	2.68	7.94	6.73	3.02	2.12	0.91	2.40
FeO	6.15	1.75	2.73	6.37	7.00	3.86	3.22
MgO	2.56	1.99	1.71	2.16	2.01	0.43	0.41
CaO	5.87	4.84	4.59	5.20	4.91	3.47	3.01
Na_2O	5.03	5.32	5.33	4.60	4.88	4.88	5.37
K_2O	4.24	5.02	5.07	4.68	5.11	6.06	5.73
TiO_2	0.78	0.86	0.89	0.88	0.86	0.56	0.66
P_2O_5	0.54	0.52	0.54	0.51	0.52	0.23	0.21
S	0.05	0.04	0.03	0.30	0.04	0.02	0.01
MnO	0.22	0.24	0.24	0.25	0.24	0.13	0.13
CO_2	0.11	0.15	0.18	0.10	0.18	0.38	0.26
H_2O+	0.20	0.02	0.07	0.17	0.22	0.22	0.40
H_2O-	0.46	0.41	0.43	0.42	0.31	0.35	0.35
Total	100.10	100.00	100.00	99.20	99.60	98.90	98.40

	Buff Syenite						
Ref. No.	136	145	144	151A	133	138	140
SiO_2	59.1	58.9	58.6	57.9	59.6	57.0	56.9
Al_2O_3	20.5	20.8	19.9	20.80	20.1	19.0	19.3
Fe_2O_3	0.90	0.79	1.11	1.40	0.88	1.62	1.39
FeO	2.74	2.25	2.82	2.25	2.74	3.94	4.43
MgO	0.34	0.42	0.47	0.34	0.42	0.75	0.64
CaO	2.88	3.17	2.91	3.22	2.95	3.49	3.15
Na_2O	4.91	5.90	5.31	6.82	6.21	5.46	6.59
K_2O	6.06	5.35	6.06	4.27	4.86	5.36	5.12
TiO_2	0.45	0.31	0.46	0.35	0.32	0.80	0.43
P_2O_5	0.16	0.16	0.17	0.24	0.14	0.35	0.28
S	<0.01	<0.01	<0.01	<0.01	0.01	0.02	0.02
MnO	0.10	0.07	0.11	0.09	0.10	0.15	0.18
CO_2	0.22	0.18	0.28	0.18	0.30	0.22	0.26
H_2O+	0.15	0.18	0.30	0.16	0.11	0.03	0.29
H_2O-	0.42	0.37	0.39	0.28	0.28	0.31	0.30
Total	98.90	98.90	98.90	98.30	99.00	98.50	99.30

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
86	KR 23-33	136	KR 22-55
89	KR 23-90	145	KR 22-192
90	KR 23-113A	144	KR 23-158
93	KR 23-248	151A	KR 21-183
95	KR 23-274	133	KR 31-5
134	KR 18-34	138	KR 33-2
148	KR 18-78	140	KR 33-5

TABLE A-2. CONTINUED.

	Buff Syenite						
Ref. No.	**62**	**63**	**64**	**67**	**68**	**73**	**79**
SiO_2	60.1	58.50	58.9	60.8	57.1	57.1	57.8
Al_2O_3	19.50	19.7	19.6	20.1	19.5	20.5	19.2
Fe_2O_3	0.76	0.89	1.31	0.85	2.73	1.14	0.24
FeO	2.3	3.36	3.43	2.24	2.87	2.94	4.20
MgO	1.4	0.87	0.91	0.40	0.80	0.78	0.73
CaO	2.84	3.69	3.10	2.39	3.56	2.81	3.10
Na_2O	5.63	5.43	5.31	5.99	6.46	7.37	5.85
K_2O	6.01	5.67	6.31	5.98	4.66	5.29	5.91
TiO_2	0.47	0.50	0.65	0.35	0.52	0.42	0.54
P_2O_5	0.20	0.23	0.27	0.19	0.30	0.29	0.25
S	<0.01	<0.01	<0.01	<0.01	0.02	<0.01	0.01
MnO	0.09	0.13	0.13	0.18	0.15	0.13	0.13
CO_2	0.12	0.11	0.22	0.16	0.11	0.13	0.10
H_2O+	0.02	0.05	0.25	0.33	0.49	0.32	0.31
H_2O-	0.40	0.41	0.48	0.42	0.43	6.41	0.39
Total	99.30	99.50	100.90	100.40	99.70	99.60	98.80

	Buff Syenite						
Ref. No.	**81**	**82**	**84**	**108**	**109**	**110**	**111**
SiO_2	61.5	58.3	55.5	60.9	60.2	58.5	59.2
Al_2O_3	20.1	20.4	19.4	19.9	19.6	19.9	19.1
Fe_2O_3	0.64	1.27	1.43	0.97	1.04	1.33	1.11
FeO	1.82	3.29	2.66	2.03	2.31	2.59	3.57
MgO	0.35	0.63	0.71	0.50	0.65	0.66	0.90
CaO	2.46	4.07	3.71	2.67	2.38	2.70	2.92
Na_2O	6.29	5.43	7.69	5.30	4.94	6.46	5.06
K_2O	6.18	5.35	5.87	6.39	6.99	5.52	6.29
TiO_2	0.28	0.41	0.43	0.36	0.31	0.49	0.56
P_2O_5	0.15	0.25	0.26	0.19	0.20	0.33	0.24
S	<0.01	0.02	<0.01	<0.01	<0.01	<0.01	<0.01
MnO	0.07	0.14	0.11	0.08	0.09	0.11	0.15
CO_2	0.13	0.10	0.20	0.10	0.14	0.16	0.10
H_2O+	0.14	0.39	0.87	0.10	0.07	0.38	0.18
H_2O-	0.32	0.28	0.30	0.34	0.50	0.49	0.48
Total	100.40	100.30	99.10	99.80	99.40	99.60	99.90

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
62	KR 18-24	81	KR 22-68B
63	KR 18-32	82	KR 22-110
64	KR 18-49	84	KR 22-135
67	KR 21-30	108	KR 30-11
68	KR 21-44	109	KR 31-21
73	KR 21-112	110	KR 31-39
79	KR 21-203	111	KR 31-49

TABLE A-2. CONTINUED.

	Buff Syenite						
Ref. No.	112	114	117	132	54	88	92
SiO_2	60.0	57.3	56.1	58.9	60.4	59.9	60.3
Al_2O_3	19.9	20.1	18.80	18.5	18.5	20.1	19.5
Fe_2O_3	0.87	0.45	1.55	1.26	1.25	1.12	1.38
FeO	2.52	3.15	4.27	3.85	3.99	2.73	2.52
MgO	0.50	0.64	0.91	0.65	0.43	0.34	0.71
CaO	3.24	2.54	3.79	2.83	2.78	2.94	2.52
Na_2O	6.15	8.18	6.84	5.36	5.99	6.09	5.55
K_2O	5.20	5.30	4.82	6.31	5.80	5.51	6.06
TiO_2	0.25	0.25	0.48	0.51	0.49	0.27	0.38
P_2O_5	0.18	0.20	0.35	0.27	0.12	0.14	0.19
S	<0.01	0.02	0.02	0.02	<0.01	<0.01	<0.01
MnO	0.09	0.14	0.20	0.17	0.12	0.12	0.13
CO_2	0.11	0.16	0.24	0.27	0.10	0.10	0.10
H_2O+	0.12	0.34	0.71	0.29	0.10	0.00	0.12
H_2O-	0.45	0.34	0.41	0.30	0.43	0.51	0.45
Total	99.70	99.60	99.50	99.50	100.50	99.90	99.90

	Buff Syenite	Red-Brown & Brown Syenite					
Ref. No.	147	141	139	146	142	137	142*
SiO_2	59.0	55.9	57.90	57.9	59.0	56.8	59.1
Al_2O_3	19.7	19.5	19.6	18.1	21.5	19.6	21.5
Fe_2O_3	1.75	2.68	1.54	3.73	0.91	1.38	0.89
FeO	2.09	3.14	3.14	2.66	1.45	4.19	1.53
MgO	0.31	1.08	0.56	0.70	0.39	0.71	0.47
CaO	3.20	3.68	3.51	2.69	3.03	4.19	2.97
Na_2O	5.21	4.98	5.63	4.30	5.09	5.56	5.11
K_2O	5.83	5.30	4.95	6.91	5.80	4.71	5.87
TiO_2	0.29	0.60	0.46	0.58	0.23	0.59	0.23
P_2O_5	0.16	0.35	0.25	0.17	0.16	0.27	0.15
S	0.03	0.04	0.01	<0.01	<0.01	0.01	<0.01
MnO	0.11	0.14	0.13	0.12	0.08	0.16	0.08
CO_2	0.34	0.30	0.18	0.26	0.30	0.26	0.30
H_2O+	0.36	0.24	0.31	0.18	0.38	0.04	0.34
H_2O-	0.31	0.35	0.36	0.35	0.36	0.32	0.36
Total	99.10	98.30	98.50	98.70	98.70	98.80	98.90

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.
* Duplicate sample

Ref. No.	Sample No.
112	KR 31-74
114	KR 33-20
117	K15X-36
132	KR 25-29
54	KR 16-17
88	KR 23-82A
92	KR 23-149

Ref. No.	Sample No.
147	KR 16-6
141	KR 16-46
139	KR 23-47
146	KR 23-50
142	KR 23-181
137	KR 23-246A
142*	KR 23-181

TABLE A-2. CONTINUED.

	Red-Brown & Brown Syenite						
Ref. No.	**1154**	**113**	**97**	**49**	**50**	**53**	**55**
SiO_2	59.6	60.2	59.9	58.8	59.8	55.5	60.2
Al_2O_3	21.2	21.3	19.4	17.7	19.6	19.1	17.2
Fe_2O_3	1.03	0.82	1.11	3.09	1.71	2.24	2.17
FeO	2.46	1.82	3.43	4.06	2.66	4.62	3.99
MgO	0.37	0.41	0.60	0.77	0.66	1.20	1.10
CaO	3.01	3.47	3.03	3.13	3.48	3.45	2.26
Na_2O	5.77	5.65	5.48	4.66	5.60	5.57	4.08
K_2O	6.04	5.35	6.12	6.35	5.06	5.63	7.15
TiO_2	0.39	0.25	0.38	0.66	0.54	0.56	0.80
P_2O_5	0.19	0.18	0.16	0.19	0.21	0.39	0.20
S	0.03	<0.01	0.01	0.02	0.03	0.02	<0.01
MnO	0.11	0.07	0.14	0.17	0.11	0.21	0.11
CO_2	0.09	0.18	0.14	0.27	0.38	0.19	0.08
H_2O+	0.17	0.18	0.31	0.32	0.06	0.29	0.12
H_2O-	0.27	0.44	0.39	0.62	0.59	0.46	0.54
Total	100.70	100.30	100.60	100.80	100.50	99.40	100.00

	Red-Brown & Brown Syenite						
Ref. No.	**56**	**57**	**58**	**61**	**65**	**66**	**80**
SiO_2	54.2	60.7	57.0	59.1	54.7	57.5	60.0
Al_2O_3	15.7	18.8	17.7	19.4	17.2	18.2	19.5
Fe_2O_3	2.69	2.10	3.67	1.59	2.43	1.94	1.52
FeO	8.20	1.68	4.34	3.15	6.72	5.25	2.24
MgO	2.75	0.48	0.71	0.79	1.65	1.42	0.61
CaO	4.66	1.85	3.28	2.80	4.55	3.20	2.45
Na_2O	5.02	6.01	4.89	5.68	4.74	4.50	4.26
K_2O	3.78	6.82	5.50	5.80	5.35	6.70	7.81
TiO_2	1.11	0.33	1.11	0.53	0.93	0.93	0.43
P_2O_5	0.76	0.17	0.35	0.27	0.58	0.28	0.23
S	0.38	0.01	0.05	<0.01	0.04	<0.01	<0.01
MnO	0.29	0.07	0.21	0.14	0.24	0.24	0.08
CO_2	0.31	0.20	0.15	0.10	0.14	0.14	0.11
H_2O+	0.07	0.03	0.02	0.31	0.23	0.56	0.23
H_2O-	0.54	0.55	0.52	0.50	0.38	0.33	0.44
Total	100.50	99.80	99.50	100.20	99.90	101.20	99.90

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
1154	KR 23-226	56	KR 16-37
113	KR 31-84	57	KR 16-42
97	KR 23-356	58	KR 16-70
49	KR 7-13	61	KR 17-8
50	KR 7-23	65	KR 18-54
53	KR 7-67	66	KR 18-62
55	KR 16-31	80	KR 21-233

TABLE A-2. CONTINUED.

	Red-Brown & Brown Syenite					
Ref. No.	87	91	94	96	78	143
SiO_2	60.6	57.0	57.8	59.1	54.5	58.0
Al_2O_3	20.0	20.4	19.0	19.1	18.7	17.6
Fe_2O_3	1.93	1.17	1.79	1.74	1.93	2.00
FeO	1.68	3.29	4.13	3.29	5.81	4.83
MgO	0.62	1.22	0.87	0.65	1.34	0.68
CaO	2.61	3.68	3.54	2.81	3.63	2.97
Na_2O	5.60	4.91	5.63	4.82	7.00	4.49
K_2O	6.04	5.39	5.52	6.51	5.08	6.12
TiO_2	0.33	0.45	0.53	0.43	0.61	0.75
P_2O_5	0.21	0.28	0.31	0.18	0.42	0.16
S	<0.01	<0.01	0.02	0.02	0.01	0.02
MnO	0.08	0.12	0.17	0.12	0.22	0.15
CO_2	0.17	0.25	0.21	0.23	0.17	0.22
H_2O+	0.00	0.45	0.43	0.32	0.42	0.38
H_2O-	0.50	0.58	0.40	0.44	0.38	0.37
Total	100.40	99.20	100.40	99.80	100.20	98.70

	Nepheline Syenite						
Ref. No.	51	52	59	60	72	105	119
SiO_2	55.5	55.6	56.6	58.9	56.0	56.7	59.1
Al_2O_3	20.8	19.6	20.8	18.9	21.2	21.5	18.4
Fe_2O_3	1.27	2.17	2.25	2.50	1.02	2.50	2.53
FeO	3.78	3.64	2.66	3.36	2.72	2.38	2.87
MgO	0.47	0.79	0.43	0.74	0.61	0.38	0.78
CaO	1.95	2.96	2.17	2.81	2.35	1.57	2.72
Na_2O	7.23	6.70	7.47	5.89	8.20	7.64	4.92
K_2O	6.53	6.21	6.83	5.66	5.36	6.63	6.94
TiO_2	0.39	0.49	0.32	0.61	2.26	0.15	0.54
P_2O_5	0.13	0.30	0.13	0.25	0.18	0.11	0.23
S	<0.01	0.02	0.01	0.02	<0.01	<0.01	<0.01
MnO	0.19	0.15	0.17	0.23	0.12	0.22	0.14
CO_2	0.12	0.28	0.29	0.20	0.25	0.48	0.22
H_2O+	0.40	0.31	0.12	0.24	0.46	0.61	0.17
H_2O-	0.43	0.46	0.44	0.37	0.40	0.47	0.45
Total	99.20	99.70	100.70	100.70	99.10	101.30	100.00

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.
87	KR 23-70
91	KR 23-134
94	KR 23-273
96	KR 23-288
78	KR 21--173B
143	KR 16-25

Ref. No.	Sample No.
51	KR 7-58
52	KR 7-66
59	KR 16-97
60	KR 16-99
72	KR 21-107
105	KR 28-30
119	K25X-6B

TABLE A-2. CONTINUED.

	Nepheline Syenite					
Ref. No.	**120**	**122**	**125**	**126**	**116**	**135**
SiO_2	58.6	55.8	58.0	59.3	52.0	56.4
Al_2O_3	19.6	20.6	19.3	18.2	15.7	20.3
Fe_2O_3	1.73	3.31	2.03	1.84	4.41	2.44
FeO	2.52	2.45	3.29	3.15	2.38	2.50
MgO	0.52	0.35	0.45	0.47	0.28	0.37
CaO	2.57	2.28	2.01	2.26	6.22	1.73
Na_2O	6.30	5.93	7.51	6.70	7.50	6.63
K_2O	6.10	6.25	6.43	6.50	6.83	6.91
TiO_2	0.38	0.36	0.36	0.47	0.30	0.37
P_2O_5	0.21	0.13	0.15	0.16	0.30	0.11
S	0.01	<0.01	0.01	<0.01	<0.01	0.05
MnO	0.16	0.17	0.17	0.15	0.33	0.18
CO_2	0.28	0.38	0.17	0.23	2.16	0.30
H_2O+	0.22	1.58	0.00	0.08	0.66	0.36
H_2O-	0.31	0.50	0.47	0.41	0.41	0.31
Total	99.50	100.10	100.40	99.90	99.50	99.00

	Nepheline Syenite		Misc. Rocks		Lamprophyre Dikes	
Ref. No.	**151**	**1153**	**115**	**83**	**A**	**B**
SiO_2	55.9	56.9	50.8	58.6	40.7	41.7
Al_2O_3	20.0	20.7	18.2	19.3	14.2	13.2
Fe_2O_3	2.21	2.08	3.05	2.19	4.33	5.35
FeO	3.30	3.23	8.60	2.80	8.48	8.95
MgO	0.32	0.43	0.91	0.89	7.36	9.06
CaO	2.20	2.13	4.64	3.42	10.4	12.20
Na_2O	7.66	6.37	5.71	5.45	1.96	2.76
K_2O	6.04	7.02	5.19	5.64	4.29	1.47
TiO_2	0.34	0.41	0.28	0.40	0.77	1.53
P_2O_5	0.11	0.11	0.37	0.22	-	-
S	0.01	0.00	0.03	0.01	0.10	0.08
MnO	0.20	0.17	0.32	0.13	0.26	0.27
CO_2	0.36	0.22	0.15	0.10	2.70	0.93
H_2O+	0.02	0.45	0.59	0.24	3.16	0.89
H_2O-	0.32	0.25	0.43	0.32	0.40	0.16
Total	99.00	100.50	99.30	99.70	99.10	98.55

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

A and B are lamprophyre dikes (Coates 1970)

Ref. No.	Sample No.	Ref. No.	Sample No.
120	K25X-40	151	KR 33-17
122	K26X-55	1153	K33X-32
125	K32X-7	115	K2D-24B
126	K32X-14B	83	KR 22-122
116	K2D-68A	A	K-25-5-3
135	KR 7-62	B	KG-35-1

TABLE A-3. TRACE ELEMENT ANALYSES (PPM) OF WHOLE-ROCK SAMPLES FROM THE KILLALA LAKE ALKALIC ROCK COMPLEX.

	Gabbro						
Ref. No.	69	70	74	75	76	77	98
Ag	<1	<1	<1	<1	<1	<1	<1
Au							
As							
Ba	110	270	170	200	360	200	260
Be	2	<1	3	<1	2	2	2
Bi							
Co	20	60	50	15	40	20	45
Cr	15	230	170	90	360	85	60
Cu	5	35	10	20	25	10	10
Ga	6	7	9	7	6	7	10
Hg							
Li	<3	10	5	5	10	5	25
Mn							
Mo	<1	<1	<1	<1	<1	<1	<1
Nb	<10	<10	<10	<10	<10	<10	<10
Ni	20	75	110	30	95	30	30
Yb							
Pb	<10	<10	10	<10	<10	<10	<10
Rb	<10	<10	20	<10	<10	<10	<10
Sb							
Sc	10	15	25	9	20	10	20
Sn	<1	<1	<1	<1	<1	<1	<1
Sr	1000	700	200	1000	800	900	300
Ti							
V	20	300	200	40	70	40	50
Y	<10	<10	35	<10	<10	<10	15
Zn	30	110	110	40	60	45	110
Zr	<10	20	70	<10	10	<10	20
La	<10	<10	150	<10	<10	<10	30
Nd	<300	<300	<300	<300	<300	<300	<300
Ce	<500	<500	<500	<500	<500	<500	<500
Eu							

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
69	KR 21-50	76	KR 21-169B
70	KR 21-73	77	KR 21-171
74	KR 21-159	98	KR 25-5
75	KR 21-162		

TABLE A-3. CONTINUED.

	Gabbro						
Ref. No.	**99**	**100**	**101**	**102**	**103**	**106**	**118**
Ag	<1	<1	<1	<1	<1	<1	<1
Au							
As							
Ba	240	180	130	180	160	160	210
Be	<1	<1	<1	1	<1	<1	<1
Bi							
Co	50	40	30	30	40	100	70
Cr	90	30	20	15	115	50	200
Cu	70	20	15	25	10	320	130
Ga	8	9	8	7	3	6	5
Hg							
Li	10	10	5	10	5	5	5
Mn							
Mo	<1	<1	<1	<1	<1	<1	<1
Nb	<10	<10	<10	<10	<10	<10	<10
Ni	80	30	40	30	70	70	10
Yb							
Pb	<10	<10	<10	<10	<10	<10	<10
Rb	<10	<10	<10	<10	<10	<10	<10
Sb							
Sc	10	15	9	10	25	30	8
Sn	<1	<1	<1	<1	<1	<1	<1
Sr	800	800	700	600	800	400	800
Ti							
V	90	100	40	50	50	200	35
Y	<10	<10	<10	<10	<10	20	<10
Zn	70	60	40	40	30	95	75
Zr	<10	<10	<10	<10	<10	20	<10
La	20	15	<10	<10	<10	<10	<10
Nd	<300	<300	<300	<300	<300	<300	<300
Ce	<500	<500	<500	<500	<500	<500	<500
Eu							

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
99	KR 25-9	103	KR 25-36
100	KR 25-12	106	KR 28-35
101	KR 25-19	118	K15X-44
102	KR 25-20B		

TABLE A-3. CONTINUED.

	Gabbro						
Ref. No.	121	123	124	127	129	130	128
Ag	<1	<1	<1	<1	<1	<1	<1
Au							
As							
Ba	250	400	200	290	330	260	280
Be	<1	<1	<1	<1	<1	<1	<1
Bi							
Co	45	35	40	65	60	55	55
Cr	80	5	10	50	70	25	15
Cu	115	20	20	220	90	20	50
Ga	7	7	5	7	7	8	6
Hg							
Li	40	5	5	5	5	10	5
Mn							
Mo	<1	<1	<1	<1	<1	<1	<1
Nb	<10	<10	<10	<10	<10	<10	<10
Ni	60	30	95	95	75	70	80
Yb							
Pb	<10	<10	<10	<10	<10	<10	<10
Rb	<10	<10	<10	<10	<10	<10	<10
Sb							
Sc	15	20	20	20	25	25	9
Sn	<1	<1	<1	<1	<1	<1	<1
Sr	800	1000	800	400	700	800	900
Ti							
V	100	200	80	150	100	200	60
Y	<10	<10	<10	10	15	10	<10
Zn	75	65	50	80	90	75	65
Zr	<10	<10	<10	25	15	20	<10
La	<10	<10	20	<10	20	<10	20
Nd	<300	<300	<300	<300	<300	<300	<300
Ce	<500	<500	<500	<500	<500	<500	<500
Eu							

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.
121	K26X-50B
123	K26X-96
124	K31X-49
127	K34X-1B
129	K34X-22
130	K34X-42B
128	K34X-12

TABLE A-3. CONTINUED.

	Gabbro	Larvikite			Monzonite		
Ref. No.	131	71	104	107	149	150	85
Ag	<1	<1	<1	<1	<1	<1	<1
Au							
As							
Ba	240	1580	1200	1470	860	940	300
Be	<1	<1	<1	<1	5	4	4
Bi							
Co	60	5	10	10	15	<5	15
Cr	45	<5	<5	<5	14	<5	20
Cu	450	10	10	15	20	5	20
Ga	8	7	7	7	15	15	8
Hg							
Li	15	5	5	5	8	9	10
Mn							
Mo	-	<1	<1	<1	<1	<1	<1
Nb	<10	<10	<10	35	150	90	100
Ni	120	<5	<5	<5	8	<5	10
Yb						1	
Pb	<10	<10	<10	<10	14	13	<10
Rb	<10	20	20	10	90	110	50
Sb							
Sc	30	20	25	25	15	<5	8
Sn	<1	<1	<1	<1	<3	<3	<1
Sr	700	400	500	400	350	300	200
Ti							
V	200	<5	<5	<5	55	<10	40
Y	<10	10	15	15	50	5	25
Zn	75	140	230	145	129	10	125
Zr	35	<10	20	35	250	150	200
La	<10	<10	<10	<10	<100	<100	45
Nd	<300	<300	<300	<300	150	<100	<300
Ce	<500	<500	<500	<500	210	50	<500
Eu					<100	<100	

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
131	K34X-49	149	KR 23-260
71	KR 21-92	150	KR 33-9
104	KR 28-23	85	KR 23-3B
107	KR 28-42		

TABLE A-3. CONTINUED.

	Monzonite					Buff Syenite	
Ref. No.	86	89	90	93	95	134	148
Ag	<1	<1	<1	<1	<1	<1	<1
Au							
As							
Ba	360	580	550	820	600	2500	2700
Be	4	4	4	3	4	4	4
Bi							
Co	20	15	15	20	20	<5	<5
Cr	15	10	10	15	10	<5	<5
Cu	25	20	15	20	20	5	6
Ga	9	9	10	9	9	15	10
Hg							
Li	5	10	10	5	5	10	7
Mn							
Mo	<1	<1	<1	<1	<1	<1	<1
Nb	150	100	100	150	150	200	100
Ni	15	<5	<5	5	5	<5	<5
Yb						2	1
Pb	10	<10	<10	<10	<10	27	23
Rb	40	60	50	50	60	80	70
Sb							
Sc	10	9	10	10	10	10	10
Sn	<1	<1	<1	<1	<1	<3	<3
Sr	500	300	400	300	300	600	500
Ti							
V	40	40	35	35	35	<10	<10
Y	30	30	35	35	35	40	20
Zn	120	130	130	130	125	82	82
Zr	250	250	250	200	200	250	200
La	50	50	70	70	50	<100	<100
Nd	<300	<300	<300	<300	<300	<100	<100
Ce	<500	<500	<500	<500	<500	90	100
Eu						<100	<100

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.
86	KR 23-33
89	KR 23-90
90	KR 23-113A
93	KR 23-248
95	KR 23-274
134	KR 18-34
148	KR 18-78

TABLE A-3. CONTINUED.

	Buff Syenite						
Ref. No.	**136**	**145**	**144**	**151A**	**133**	**138**	**140**
Ag	<1	<1	<1	<1	<1	<1	<1
Au							
As							
Ba	2300	1900	2300	2200	1400	1900	1600
Be	<1	<1	<1	4	3	2	4
Bi							
Co	<5	<5	<5	<5	<5	<5	7
Cr	<5	<5	<5	<5	6	<5	<5
Cu	5	6	6	9	6	8	8
Ga	9	10	10	15	10	9	15
Hg							
Li	6	6	6	<3	10	6	12
Mn							
Mo	<1	<1	<1	<1	<1	<1	<1
Nb	80	100	100	150	100	150	300
Ni	<5	<5	<5	<5	<5	<5	<5
Yb	<1	<1	<1	<1	<1	1	2
Pb	19	19	11	13	14	<10	12
Rb	60	60	50	50	60	50	80
Sb							
Sc	7	<5	9	<5	5	9	6
Sn	<3	<3	<3	<3	<3	<3	<3
Sr	500	900	600	800	500	600	600
Ti							
V	<10	15	<10	<10	<10	<10	20
Y	20	20	30	30	20	30	45
Zn	58	42	59	70	58	78	118
Zr	100	150	150	150	150	200	300
La	<100	<100	<100	150	<100	100	150
Nd	<100	<100	<100	150	<100	<100	150
Ce	90	70	340	100	60	200	240
Eu	<100	<100	<100	<100	<100	<100	<100

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
136	KR 22-55	133	KR 31-5
145	KR 22-192	138	KR 33-2
144	KR 23-158	140	KR 33-5
151A	KR 21-183		

TABLE A-3. CONTINUED.

	Buff Syenite						
Ref. No.	62	63	64	67	68	73	79
Ag	<1	<1	<1	<1	<1	<1	<1
Au							
As							
Ba	1640	2160	1440	1060	240	1410	1740
Be	2	3	3	2	3	3	2
Bi							
Co	<5	<5	<5	<5	5	<5	<5
Cr	<5	<5	<5	<5	<5	<5	<5
Cu	<5	5	5	5	10	5	5
Ga	9	9	9	5	7	6	7
Hg							
Li	5	10	15	10	10	15	5
Mn							
Mo	<1	<1	<1	<1	<1	<1	<1
Nb	80	100	150	<10	100	90	90
Ni	<5	<5	<5	<5	<5	<5	<5
Yb							
Pb	<10	10	<10	<10	10	<10	<10
Rb	70	70	60	80	70	80	60
Sb							
Sc	9	9	9	<5	<5	<5	6
Sn	<1	<1	<1	<1	<1	<1	<1
Sr	600	600	700	400	500	500	500
Ti							
V	<5	<5	<5	<5	<5	<5	<5
Y	15	20	20	<10	20	<10	10
Zn	55	75	75	55	120	70	75
Zr	60	90	100	30	150	60	70
La	45	50	60	<10	60	<10	<10
Nd	<300	<300	<300	<300	<300	<300	<300
Ce	<500	<500	<500	<500	<500	<500	<500
Eu							

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
62	KR 18-24	68	KR 21-44
63	KR 18-32	73	KR 21-112
64	KR 18-49	79	KR 21-203
67	KR 21-30		

TABLE A-3. CONTINUED.

	Buff Syenite						
Ref. No.	**81**	**82**	**84**	**108**	**109**	**110**	**111**
Ag	<1	<1	<1	<1	<1	<1	<1
Au							
As							
Ba	1200	1540	980	1940	1830	1760	1120
Be	3	2	5	2	2	4	2
Bi							
Co	<5	5	5	<5	10	10	5
Cr	<5	<5	<5	<5	<5	<5	<5
Cu	<5	5	5	5	5	5	5
Ga	7	7	7	6	6	6	6
Hg							
Li	10	5	55	10	15	20	10
Mn							
Mo	<1	<1	<1	<1	<1	<1	<1
Nb	50	80	30	50	45	100	100
Ni	<5	<5	<5	<5	<5	<5	<5
Yb							
Pb	10	<10	25	<10	<10	<10	<10
Rb	90	70	240	50	50	50	50
Sb							
Sc	<5	<5	<5	<10	5	<5	8
Sn	<1	<1	<1	<1	<1	<1	<1
Sr	400	600	600	500	500	700	400
Ti							
V	<5	<5	<5	<5	<5	<5	<5
Y	<10	10	<10	10	10	20	15
Zn	50	70	60	50	55	80	85
Zr	60	80	40	45	45	100	150
La	<10	<10	<10	15	30	<10	<10
Nd	<300	<300	<300	<300	<300	<300	<300
Ce	<500	<500	<500	<500	<500	<500	<500
Eu							

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
81	KR 22-68B	109	KR 31-21
82	KR 22-110	110	KR 31-39
84	KR 22-135	111	KR 31-49
108	KR 30-11		

TABLE A-3. CONTINUED.

	Buff Syenite						
Ref. No.	112	114	117	132	54	88	92
Ag	<1	<1	<1	<1	<1	<1	<1
Au							
As							
Ba	860	950	960	1180	550	1110	780
Be	3	4	5	2	4	4	3
Bi							
Co	<5	5	10	5	<5	<5	5
Cr	<5	<5	<5	<5	<5	<5	<5
Cu	5	5	5	10	10	5	5
Ga	8	7	6	7	15	9	7
Hg							
Li	10	15	15	10	15	10	20
Mn							
Mo	<1	<1	<1	<1	<1	<1	<1
Nb	60	100	100	90	250	70	60
Ni	<5	<5	<5	<5	<5	<5	<5
Yb							
Pb	<10	<10	10	<10	20	10	<10
Rb	40	90	60	60	160	110	40
Sb							
Sc	5	<5	5	5	8	<5	5
Sn	<1	<1	<1	<1	<1	<1	<1
Sr	500	500	600	500	300	300	300
Ti							
V	<5	<5	<5	<5	<5	<5	<5
Y	15	20	25	<10	40	20	15
Zn	70	90	110	85	105	85	70
Zr	80	100	150	100	700	200	80
La	<10	35	70	35	60	30	30
Nd	<300	<300	<300	<300	<300	<300	<300
Ce	<500	<500	<500	<500	<500	<500	<500
Eu							

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
112	KR 31-74	54	KR 16-17
114	KR 33-20	88	KR 23-82A
117	K15X-36	92	KR 23-149
132	KR 25-29		

TABLE A-3. CONTINUED.

	Buff Syenite	Red-Brown & Brown Syenite					
Ref. No.	147	141	139	146	142	137	142*
Ag	<1	<1	<1	<1	<1	<1	<1
Au							
As							
Ba	1900	2200	1500	1200	2200	780	2200
Be	<1	<1	<1	<1	<1	4	<1
Bi							
Co	<5	7	<5	<5	<5	<5	<5
Cr	<5	<5	<5	<5	<5	<5	<5
Cu	8	8	6	6	6	6	6
Ga	10	10	10	9	15	15	10
Hg							
Li	4	6	6	10	14	13	16
Mn							
Mo	<1	<1	<1	<1	<1	<1	<1
Nb	<30	<30	70	50	<30	150	<30
Ni	<5	<5	<5	<5	<5	<5	<5
Yb	<1	2	<1	<1	<1	2	<1
Pb	40	22	12	16	11	11	12
Rb	80	60	60	70	50	120	60
Sb							
Sc	5	10	7	10	<5	10	<5
Sn	<3	<3	<3	<3	<3	<3	<3
Sr	600	600	700	400	900	450	1000
Ti							
V	<10	15	15	<10	<10	15	<10
Y	15	30	30	20	15	40	10
Zn	50	84	64	84	30	111	30
Zr	40	90	100	150	40	200	35
La	<100	<100	<100	<100	<100	<100	<100
Nd	<100	<100	100	<100	<100	<100	<100
Ce	<50	110	130	130	<50	490	<50
Eu	<100	<100	<100	<100	<100	<100	<100

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories Ontario Geological Survey, Toronto.
* Duplicate sample

Ref. No.	Sample No.	Ref. No.	Sample No.
147	KR 16-6	142	KR 23-181
141	KR 16-46	137	KR 23-246A
139	KR 23-47	142*	KR 23-181
146	KR 23-50		

TABLE A-3. CONTINUED.

	Red-Brown & Brown Syenite						
Ref. No.	1154	113	97	49	50	53	55
Ag	<1	<1	<1	<1	<1	<1	<1
Au							
As							
Ba	1600	1060	730	780	940	900	520
Be	<1	2	3	2	2	4	3
Bi							
Co	6	<5	5	5	<5	10	5
Cr	<5	<5	<5	<5	<5	<5	<5
Cu	8	<5	10	10	5	10	10
Ga	10	7	10	8	10	10	15
Hg							
Li	9	10	15	15	10	25	25
Mn							
Mo	<1	<1	<1	<1	<1	<1	<1
Nb	<30	<10	80	80	45	150	150
Ni	<5	<5	<5	<5	<5	<5	<5
Yb	<1	-	-				
Pb	20	<10	<10	20	30	<10	10
Rb	60	40	70	80	40	90	70
Sb							
Sc	<5	<5	5	10	10	7	20
Sn	<3	<1	<1	<1	<1	<1	<1
Sr	600	900	300	300	700	800	300
Ti							
V	<10	<5	<5	<5	<5	35	<5
Y	<10	<10	20	25	15	35	40
Zn	68	45	80	90	65	120	80
Zr	80	25	100	150	60	200	250
La	<100	35	35	<10	<10	100	80
Nd	<100	<300	<300	<300	<300	<300	<300
Ce	680	<500	<500	<500	<500	<500	<500
Eu	<100	-	-				

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
1154	KR 23-226	50	KR 7-23
113	KR 31-84	53	KR 7-67
97	KR 23-356	55	KR 16-31
49	KR 7-13		

TABLE A-3. CONTINUED.

	Red-Brown & Brown Syenite					
Ref. No.	**56**	**57**	**58**	**61**	**65**	**66**
Ag	<1	<1	<1	<1	<1	<1
Au						
As						
Ba	740	320	920	1380	580	580
Be	<1	3	<1	2	3	3
Bi						
Co	20	<5	10	5	10	5
Cr	30	<5	<5	<5	<5	<5
Cu	25	<5	10	5	10	<5
Ga	15	10	9	9	10	6
Hg						
Li	10	5	3	10	5	20
Mn						
Mo	<1	<1	<1	<1	<1	<1
Nb	25	25	90	100	150	200
Ni	5	<5	<5	<5	<5	<5
Yb						
Pb	<10	<10	<10	<10	<10	<10
Rb	20	130	60	80	60	40
Sb						
Sc	20	5	8	8	10	15
Sn	<1	<1	<1	<1	<1	<1
Sr	600	200	400	500	400	300
Ti						
V	60	<5	<5	<5	40	<5
Y	35	15	15	30	35	30
Zn	170	45	110	80	120	110
Zr	80	50	50	70	200	200
La	70	35	25	70	70	60
Nd	<300	<300	<300	<300	<300	<300
Ce	<500	<500	<500	<500	<500	<500
Eu						

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
56	KR 16-37	61	KR 17-8
57	KR 16-42	65	KR 18-54
58	KR 16-70	66	KR 18-62

TABLE A-3. CONTINUED.

	Red-Brown & Brown Syenite					
Ref. No.	80	87	91	94	96	78
Ag	<1	<1	<1	<1	<1	<1
Au						
As						
Ba	1030	920	1000	920	880	800
Be	2	2	2	3	3	4
Bi						
Co	<5	5	10	5	10	10
Cr	<5	<5	<5	<5	<5	<5
Cu	5	5	10	10	10	10
Ga	7	7	8	9	8	8
Hg						
Li	20	10	20	10	15	20
Mn						
Mo	<1	<1	<1	<1	<1	<1
Nb	40	30	50	200	60	150
Ni	<5	<5	<5	<5	<5	<5
Yb						
Pb	<10	<10	<10	<10	<10	<10
Rb	70	70	40	60	80	60
Sb						
Sc	<5	<5	<5	<5	<5	7
Sn	<1	<1	<1	<1	<1	<1
Sr	300	500	800	400	200	400
Ti						
V	<5	<5	<5	<5	<5	30
Y	<10	10	10	25	20	30
Zn	60	55	55	110	70	125
Zr	40	30	60	150	90	200
La	<10	20	45	50	30	60
Nd	<300	<300	<300	<300	<300	<300
Ce	<500	<500	<500	<500	<500	<500
Eu						

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
80	KR 21-233	94	KR 23-273
87	KR 23-70	96	KR 23-288
91	KR 23-134	78	KR 21--173B

TABLE A-3. CONTINUED.

	Red-Brown & Brown Syenite	Nepheline Syenite				
Ref. No.	143	51	52	59	60	72
Ag	<1	<1	<1	<1	<1	<1
Au						
As						
Ba	1300	110	500	100	940	840
Be	5	3	3	4	4	4
Bi						
Co	<5	<5	5	<5	5	5
Cr	<5	<5	<5	<5	<5	<5
Cu	11	<5	5	<5	5	<5
Ga	15	8	8	7	8	7
Hg						
Li	11	10	10	10	10	20
Mn						
Mo	<1	<1	<1	<1	<1	<1
Nb	300	150	150	70	90	90
Ni	<5	<5	<5	<5	<5	<5
Yb	6					
Pb	38	40	<10	<10	<10	10
Rb	130	120	90	80	70	100
Sb						
Sc	15	6	5	5	<5	<5
Sn	<3	<1	<1	<1	<1	<1
Sr	350	30	400	50	600	400
Ti						
V	<10	<5	<20	<5	<5	<5
Y	80	25	20	10	15	15
Zn	110	95	100	70	95	85
Zr	2000	150	150	100	200	90
La	150	50	60	<10	50	30
Nd	250	<300	<300	<300	<300	<300
Ce	310	<500	<500	<500	<500	<500
Eu	<100					

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
143	KR 16-25	59	KR 16-97
51	KR 7-58	60	KR 16-99
52	KR 7-66	72	KR 21-107

TABLE A-3. CONTINUED.

	Nepheline Syenite					
Ref. No.	105	119	120	122	125	126
Ag	<1	<1	<1	<1	<1	<1
Au						
As						
Ba	80	1030	1480	100	530	800
Be	4	2	2	3	3	3
Bi						
Co	5	5	<5	<5	5	5
Cr	<5	<5	<5	<5	<5	<5
Cu	10	5	<5	10	5	5
Ga	5	6	5	6	7	7
Hg						
Li	10	10	10	10	20	15
Mn						
Mo	<1	<1	<1	<1	<1	-
Nb	150	80	45	45	150	100
Ni	<5	<5	<5	<5	<5	<5
Yb						
Pb	<10	<10	<10	<10	<10	<10
Rb	100	50	60	70	120	130
Sb						
Sc	<5	7	<5	<5	5	5
Sn	<1	<1	<1	<1	<1	<1
Sr	50	400	400	300	200	200
Ti						
V	<5	<5	<5	<5	<5	<5
Y	20	10	15	15	20	15
Zn	85	70	70	85	95	90
Zr	150	80	50	70	150	100
La	35	20	35	<10	<10	<10
Nd	<300	<300	<300	<300	<300	<300
Ce	<500	<500	<500	<500	<500	<500
Eu						

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
105	KR 28-30	122	K26X-55
119	K25X-6B	125	K32X-7
120	K25X-40	126	K32X-14B

TABLE A-3. CONTINUED.

	Nepheline Syenite				Misc. Rocks	
Ref. No.	**116**	**135**	**151**	**1153**	**115**	**83**
Ag	<1	<1	<1	<1	<1	<1
Au						
As						
Ba	430	180	800	270	2040	900
Be	15	4	5	<1	4	<1
Bi						
Co	5	<5	<5	6	15	5
Cr	<5	10	<5	<5	<5	<5
Cu	<5	7	5	7	25	10
Ga	20	9	15	8	4	6
Hg						
Li	10	8	12	10	10	3
Mn						
Mo	<1	<1	<1	<1	<1	<1
Nb	600	200	200	100	150	150
Ni	<5	<5	<5	<5	<5	<5
Yb		1	2	<1		
Pb	10	60	12	19	<10	<10
Rb	170	90	110	90	100	60
Sb						
Sc	15	10	<5	8	<5	<5
Sn	1	<3	<3	<3	<1	<1
Sr	700	100	250	150	1500	600
Ti						
V	30	<10	<10	<10	<5	<5
Y	45	35	30	25	20	15
Zn	250	70	114	67	80	65
Zr	>0.01%	>0.01%	200	200	200	80
La	45	<100	<100	<100	25	<10
Nd	<300	<100	<100	<100	<300	<300
Ce	<500	150	160	180	<500	<500
Eu		<100	<100	<100		

Notes: For sample descriptions, see Table A-1. Analyses by Geoscience Laboratories, Ontario Geological Survey, Toronto.

Ref. No.	Sample No.	Ref. No.	Sample No.
116	K2D-68A	1153	K33X-32
135	KR 7-62	115	K2D-24B
151	KR 33-17	83	KR 22-122

TABLE A-4. NORMATIVE MINERALS (CIPW NORM) FOR WHOLE-ROCK SAMPLES FROM THE KILLALA LAKE ALKALIC ROCK COMPLEX.

	Gabbro						
Ref. No.	69	70	74	75	76	77	98
S.G.	2.85	3.11	3.09	2.82	2.97	2.88	3.01
AP	0.233	2.549	0.349	1.080	1.002	0.586	0.442
PO		0.246		0.055	0.055		
IL	0.229	2.485	2.417	0.692	0.706	0.518	2.495
OR	3.564	2.009	2.845	3.591	2.556	2.091	2.373
AB	15.193	21.730	27.959	21.818	16.029	13.253	32.070
AN	51.870	31.395	20.861	49.989	37.847	55.526	22.025
C							
AC							
MT	2.242	7.735	6.008	2.436	2.171	3.119	5.423
HM		7.550	6.978				
WO							
EN							5.703
FS							3.908
Q							
DI	12.035	11.622	27.496	6.459	15.005	1.389	13.801
FO	2.803	9.664	2.783	2.617	8.294	3.139	2.002
FA	0.856			1.565	4.266	1.355	1.512
NE	8.064	3.015	2.305	6.640	5.962	5.135	
LC							
KP							
HE	2.910			3.057	6.107	3.888	8.245
CC							
RU							
NS							
KS							
CR							
LN							

S.G. - Specific Gravity; AP - Apatite; PO - Pyrrhotite; IL - Ilmenite; OR - Orthoclase; AB - Albite; AN - Anorthite; C - Corundum; AC - Acmite; MT - Magnetite; HM - Hematite; WO - Wollastonite; EN - Enstatite; FS - Ferrosilite; Q - Quartz; DI - Diopside; FO - Forsterite; FA - Fayalite; NE - Nepheline; LC - Leucite; KP - Kaliophilite; HE - Hedenbergite; CC - Calcite; RU - Rutile; NS - Na_2SiO_3; KS - Kalsilite; CR - Chromite; LN - Larnite.

For sample descriptions, see Table A-1.

Ref. No.	Sample No.	Ref. No.	Sample No.
69	KR 21-50	76	KR 21-169B
70	KR 21-73	77	KR 21-171
74	KR 21-159	98	KR 25-5
75	KR 21-162		

TABLE A-4. CONTINUED.

	Gabbro						
Ref. No.	**99**	**100**	**101**	**102**	**103**	**106**	**118**
S.G.	2.95	2.96	2.83	2.85	2.93	3.30	2.95
AP	0.845	1.679	0.398	0.539	0.515	2.888	1.031
PO	0.166	0.110		0.028		0.056	0.138
IL	1.326	1.699	0.537	0.595	0.479	2.682	0.652
OR	3.111	2.319	2.091	3.885	2.505	1.142	2.329
AB	21.319	19.459	20.906	18.128	16.122	7.746	19.553
AN	39.472	37.563	54.765	48.816	44.110	21.464	41.547
C							
AC							
MT	4.884	4.503	2.549	2.666	2.163	9.295	1.976
HM							
WO							
EN							
FS							
Q							
DI	7.525	10.460	7.214	11.288	18.764	20.921	3.664
FO	9.559	4.846	4.109	2.381	4.759	12.353	16.781
FA	5.984	3.704	2.250	1.151	1.818	8.141	9.956
NE	2.081	7.333	2.056	6.203	3.095	2.463	0.652
LC							
KP							
HE	3.727	6.326	3.125	4.319	5.671	10.909	1.720
CC							
RU							
NS							
KS							
CR							
LN							

For sample descriptions, see Table A-1.

Ref. No.	Sample No.	Ref. No.	Sample No.
99	KR 25-9	103	KR 25-36
100	KR 25-12	106	KR 28-35
101	KR 25-19	118	K15X-44
102	KR 25-20B		

TABLE A-4. CONTINUED.

	Gabbro						
Ref. No.	121	123	124	127	129	130	128
S.G.	2.97	2.91	2.93	3.06	3.09	3.06	2.91
AP	1.863	1.181	0.862	2.605	1.909	1.877	0.871
PO	0.279		0.110	0.140	0.167		0.084
IL	1.931	2.572	0.896	1.803	1.466	1.671	0.964
OR	2.646	3.252	2.198	2.416	1.442	6.163	2.282
AB	21.822	32.995	21.918	16.099	17.132	7.982	25.936
AN	38.572	36.440	41.251	30.833	28.620	21.836	41.605
C							
AC							
MT	5.617	6.200	2.693	4.885	5.391	5.030	2.914
HM							
WO							
EN			1.550				0.244
FS			0.725				0.142
Q							
DI	9.224	5.468	11.240	13.004	18.178	19.127	4.483
FO	7.082	4.726	7.896	7.856	8.648	5.136	11.092
FA	4.634	3.328	4.073	6.430	5.725	3.944	7.110
NE	1.553			5.506	1.800	15.611	
LC							
KP							
HE	4.776	3.046	4.587	8.421	9.521	11.621	2.274
CC							
RU							
NS							
KS							
CR							
LN							

For sample descriptions, see Table A-1.

Ref. No.	Sample No.	Ref. No.	Sample No.
121	K26X-50B	129	K34X-22
123	K26X-96	130	K34X-42B
124	K31X-49	128	K34X-12
127	K34X-1B		

TABLE A-4. CONTINUED.

	Gabbro	Larvikite			Monzonite		
Ref. No.	**131**	**71**	**104**	**107**	**149**	**150**	**85**
S.G.	3.07	2.83	2.82	2.86	2.83	2.69	2.83
AP	0.282	1.005	0.935	1.127	1.156	0.307	1.170
PO	0.028	0.166	0.138	0.139	0.112	0.028	0.083
IL	2.654	2.507	2.239	3.382	1.603	0.599	1.609
OR	2.216	24.255	24.611	22.564	29.048	36.789	29.474
AB	18.630	44.242	46.585	42.206	30.752	29.511	29.281
AN	31.099	8.395	5.854	9.129	11.760	3.416	9.479
C							
AC							
MT	5.873	5.619	4.119	8.362	3.066	3.055	3.612
HM		4.175					
WO		0.731					
EN				1.245			
FS				1.638			
Q		2.357		1.035			
DI	15.832	6.549	2.417	4.272	3.166	0.891	4.543
FO	7.051		1.026		2.591	0.244	2.414
FA	5.305		4.110		5.565	1.425	4.136
NE	1.604		0.299		5.803	19.612	8.040
LC							
KP							
HE	9.425		7.666	4.901	5.380	4.123	6.158
CC							
RU							
NS							
KS							
CR							
LN							

For sample descriptions, see Table A-1.

Ref. No.	Sample No.	Ref. No.	Sample No.
131	K34X-49	149	KR 23-260
71	KR 21-92	150	KR 33-9
104	KR 28-23	85	KR 23-3B
107	KR 28-42		

TABLE A-4. CONTINUED.

	Monzonite					Buff Syenite	
Ref. No.	86	89	90	93	95	134	148
S.G.	2.84	2.83	2.82	2.84	2.83	2.70	2.69
AP	1.262	1.214	1.261	1.201	1.220	0.545	0.500
PO	0.138	0.110	0.083	0.084	0.111	0.056	0.028
IL	1.492	1.643	1.701	1.697	1.652	1.086	1.288
OR	25.257	29.872	30.186	28.107	30.570	36.598	34.817
AB	30.331	33.729	35.797	33.094	29.997	38.089	41.551
AN	13.830	7.715	7.800	12.088	9.484	13.672	10.537
C							
AC							
MT	3.913	3.664	6.830	4.446	3.109	1.347	3.575
HM		5.461	2.063				
WO							
EN							
FS							
Q							
DI	4.755	10.133	9.001	3.889	3.624	0.372	0.808
FO	2.954	0.202	0.079	2.564	2.370	0.645	0.472
FA	4.083	0.000		4.250	5.200	3.701	1.551
NE	6.786	6.258	5.198	3.479	6.372	2.203	2.774
LC		0.000					
KP		0.000					
HE	5.199	0.000		5.101	6.291	1.686	2.099
CC		0.000					
RU		0.000					
NS							
KS							
CR							
LN							

For sample descriptions, see Table A-1.

Ref. No.	Sample No.	Ref. No.	Sample No.
86	KR 23-33	95	KR 23-274
89	KR 23-90	134	KR 18-34
90	KR 23-113A	148	KR 18-78
93	KR 23-248		

TABLE A-4. CONTINUED.

	Buff Syenite						
Ref. No.	**136**	**145**	**144**	**151A**	**133**	**138**	**140**
S.G.	2.67	2.66	2.67	2.68	2.65	2.73	2.72
AP	0.378	0.378	0.403	0.570	0.330	0.829	0.660
PO	0.028	0.028	0.028	0.028	0.028	0.056	0.056
IL	0.871	0.600	0.892	0.680	0.618	1.551	0.830
OR	36.522	32.250	36.604	25.856	29.236	32.374	30.770
AB	42.327	43.669	40.622	47.720	48.664	40.384	38.168
AN	13.491	14.736	12.818	13.844	12.821	11.736	8.077
C	1.025						
AC							
MT	1.330	1.167	1.643	2.078	1.298	2.398	2.048
HM							
WO							
EN	0.403						
FS	1.758						
Q							
DI		0.054	0.181	0.215	0.229	0.953	1.123
FO	0.322	0.729	0.779	0.538	0.671	1.027	0.770
FA	1.546	2.349	2.687	1.766	2.773	2.892	3.476
NE		3.902	2.848	6.148	2.585	3.677	10.012
LC							
KP							
HE		0.138	0.495	0.558	0.747	2.123	4.010
CC							
RU							
NS							
KS							
CR							
LN							

For sample descriptions, see Table A-1.

Ref. No.	Sample No.	Ref. No.	Sample No.
136	KR 22-55	133	KR 31-5
145	KR 22-192	138	KR 33-2
144	KR 23-158	140	KR 33-5
151A	KR 21-183		

TABLE A-4. CONTINUED.

	Buff Syenite						
Ref. No.	62	63	64	67	68	73	79
S.G.	2.66	2.70	2.70	2.65	2.70	2.70	2.68
AP	0.470	0.539	0.627	0.443	0.705	0.681	0.592
PO					0.056		0.028
IL	0.904	0.959	1.235	0.668	1.001	0.808	1.047
OR	35.999	33.887	37.353	35.560	27.938	31.680	35.687
AB	43.741	39.001	37.463	45.424	42.855	36.163	36.375
AN	10.301	12.752	11.003	10.337	10.580	7.310	8.843
C							
AC							
MT	1.410	1.304	1.901	1.239	4.012	1.673	0.355
HM							
WO							
EN							
FS							
Q							
DI	0.873	1.216	0.825	0.076	2.185	1.479	1.047
FO	0.848	1.139	1.321	0.677	0.705	0.898	0.960
FA	1.664	2.811	2.818	2.373	0.918	2.040	3.972
NE	2.435	4.019	4.062	2.993	6.795	14.609	7.667
LC							
KP							
HE	1.356	2.374	1.391	0.210	2.250	2.659	3.427
CC							
RU							
NS							
KS							
CR							
LN							

For sample descriptions, see Table A-1.

Ref. No.	Sample No.	Ref. No.	Sample No.
62	KR 18-24	68	KR 21-44
63	KR 18-32	73	KR 21-112
64	KR 18-49	79	KR 21-203
67	KR 21-30		

TABLE A-4. CONTINUED.

	Buff Syenite						
Ref. No.	81	82	84	108	109	110	111
S.G.	2.65	2.69	2.67	2.65	2.66	2.69	2.69
AP	0.349	0.583	0.617	0.444	0.470	0.776	0.562
PO		0.055					
IL	0.533	0.782	0.835	0.689	0.596	0.944	1.073
OR	36.613	31.788	35.513	38.067	41.886	33.117	37.543
AB	44.289	39.672	26.219	44.087	40.077	42.116	39.922
AN	8.358	15.547	1.092	11.704	10.635	9.116	10.909
C					0.054		
AC							
MT	0.929	1.850	2.121	1.416	1.528	1.956	1.624
HM							
WO			1.706				
EN							
FS							
Q							
DI	0.709	0.757	3.901	0.119		0.735	0.613
FO	0.382	0.858		0.840	1.149	0.929	1.386
FA	1.197	2.710		1.845	2.377	1.902	3.402
NE	4.883	3.509	21.846	0.582	1.227	7.216	1.776
LC							
KP							
HE	1.759	1.890	6.151	0.206		1.191	1.191
CC							
RU							
NS							
KS							
CR							
LN							

For sample descriptions, see Table A-1.

Ref. No.	Sample No.	Ref. No.	Sample No.
81	KR 22-68B	109	KR 31-21
82	KR 22-110	110	KR 31-39
84	KR 22-135	111	KR 31-49
108	KR 30-11		

TABLE A-4. CONTINUED.

	Buff Syenite						
Ref. No.	112	114	117	132	54	88	92
S.G.	2.65	2.68	2.73	2.70	2.69	2.65	2.66
AP	0.422	0.470	0.827	0.635	0.279	0.327	0.444
PO		0.056	0.056	0.056			
IL	0.671	0.481	0.929	0.982	0.932	0.517	0.727
OR	31.068	31.743	29.056	37.845	34.351	32.834	36.119
AB	46.144	34.574	36.202	39.380	43.773	44.424	44.673
AN	11.439	2.495	6.471	7.877	6.457	11.307	10.463
C							
AC							
MT	1.274	1.395	2.290	1.852	1.815	1.636	2.016
HM							
WO							
EN							
FS							
Q							
DI	0.895	2.125	2.657	1.002	1.011	0.429	0.294
FO	0.591	0.441	0.755	0.825	0.423	0.458	1.153
FA	1.829	1.452	2.225	3.044	2.485	2.307	2.229
NE	3.475	19.232	12.339	3.577	3.777	4.055	1.432
LC							
KP							
HE	2.192	5.538	6.192	2.925	4.698	1.706	0.449
CC							
RU							
NS							
KS							
CR							
LN							

For sample descriptions, see Table A-1.

Ref. No.	Sample No.	Ref. No.	Sample No.
112	KR 31-74	54	KR 16-17
114	KR 33-20	88	KR 23-82A
117	K15X-36	92	KR 23-149
132	KR 25-29		

TABLE A-4. CONTINUED.

	Buff Syenite	Red-Brown & Brown Syenite					
Ref. No.	147	141	139	146	142	137	142*
S.G.	2.66	2.73	2.70	2.69	2.65	2.73	2.65
AP	0.378	0.834	0.594	0.403	0.380	0.638	0.355
PO	0.084	0.113	0.028	0.028	0.028	0.028	0.028
IL	0.562	1.170	0.894	1.126	0.447	1.141	0.446
OR	35.165	32.196	29.976	41.764	35.134	28.380	35.464
AB	44.623	39.701	44.967	37.174	44.104	40.851	44.159
AN	13.394	15.599	13.902	9.871	14.322	14.876	14.047
C					1.760		1.731
AC							
MT	2.587	3.991	2.286	5.526	1.351	2.038	1.318
HM							
WO							
EN				1.126	0.703		0.295
FS				0.664	1.186		0.455
Q				0.180			
DI	0.453	0.355	0.557	1.413		0.997	
FO	0.404	1.820	0.820		0.205	0.938	0.631
FA	1.152	1.982	2.549		0.380	3.413	1.070
NE	0.177	1.934	2.059			3.830	
LC							
KP							
HE	1.021	0.305	1.369	0.726		2.870	
CC							
RU							
NS							
KS							
CR							
LN							

For sample descriptions, see Table A-1.
* Duplicate sample

Ref. No.	Sample No.	Ref. No.	Sample No.
147	KR 16-6	142	KR 23-181
141	KR 16-46	137	KR 23-246A
139	KR 23-47	142*	KR 23-181
146	KR 23-50		

TABLE A-4. CONTINUED.

	Red-Brown & Brown Syenite						
Ref. No.	1154	113	97	49	50	53	55
S.G.	2.67	2.66	2.71	2.72	2.68	2.72	2.64
AP	0.440	0.420	0.372	0.443	0.490	0.919	0.467
PO	0.082		0.027	0.055	0.083	0.056	
IL	0.739	0.477	0.723	1.259	1.031	1.080	1.531
OR	35.660	31.798	36.288	37.714	30.097	33.815	42.607
AB	40.024	45.985	40.709	39.589	47.644	33.273	34.777
AN	13.664	16.114	10.272	8.644	13.463	10.635	7.538
C	0.148	0.335					
AC							
MT	1.491	1.195	1.613	4.499	2.493	3.298	3.170
HM							
WO							
EN				0.405	0.228		2.365
FS				0.855	0.368		3.813
Q							1.682
DI			0.825	1.702	0.877	1.276	0.852
FO	0.645	0.719	0.781	0.512	0.714	1.712	
FA	2.392	1.848	2.866	1.192	1.274	3.798	
NE	4.715	1.110	3.125			7.898	
LC							
KP							
HE			2.396	3.132	1.238	2.241	1.198
CC							
RU							
NS							
KS							
CR							
LN							

For sample descriptions, see Table A-1.

Ref. No.	Sample No.	Ref. No.	Sample No.
1154	KR 23-226	50	KR 7-23
113	KR 31-84	53	KR 7-67
97	KR 23-356	55	KR 16-31
49	KR 7-13		

TABLE A-4. CONTINUED.

	Red-Brown & Brown Syenite					
Ref. No.	**56**	**57**	**58**	**61**	**65**	**66**
S.G.	2.88	2.64	2.74	2.67	2.81	2.75
AP	1.774	0.398	0.822	0.631	1.357	0.648
PO	1.049	0.028	0.139		0.111	
IL	2.122	0.633	2.134	1.014	1.782	1.763
OR	22.504	40.741	32.932	34.566	31.928	39.566
AB	41.287	42.520	41.881	42.562	32.076	32.400
AN	9.194	4.203	10.214	10.374	9.930	9.641
C						
AC						
MT	3.926	3.075	5.386	2.323	3.555	2.808
HM						
WO						
EN			0.825			
FS			1.535			
Q						
DI	3.347	1.956	1.269	0.575	2.617	1.366
FO	3.743	0.211	0.264	1.202	2.055	2.030
FA	6.010	0.174	0.541	2.597	5.004	4.397
NE	0.792	4.786		3.173	4.543	3.040
LC						
KP						
HE	4.252	1.275	2.059	0.983	5.041	2.340
CC						
RU						
NS						
KS						
CR						
LN						

For sample descriptions, see Table A-1.

Ref. No.	Sample No.	Ref. No.	Sample No.
56	KR 16-37	61	KR 17-8
57	KR 16-42	65	KR 18-54
58	KR 16-70	66	KR 18-62

TABLE A-4. CONTINUED.

	Red-Brown & Brown Syenite					
Ref. No.	80	87	91	94	96	78
S.G.	2.66	2.67	2.69	2.71	2.68	2.75
AP	0.538	0.489	0.663	0.724	0.423	0.982
PO				0.055	0.056	0.028
IL	0.824	0.629	0.873	1.014	0.827	1.167
OR	46.601	35.834	32.562	32.880	38.990	30.276
AB	35.748	45.722	39.644	38.901	39.905	28.816
AN	10.743	11.609	16.774	10.329	11.379	4.625
C	0.129	0.003	0.475			
AC						
MT	2.223	2.807	1.733	2.614	2.554	2.820
HM						
WO						
EN						
FS						
Q						
DI				1.417	0.415	2.862
FO	1.074	1.085	2.175	1.069	1.014	1.426
FA	1.789	0.848	3.593	2.970	2.785	3.973
NE	0.331	0.976	1.508	4.912	0.751	16.716
LC						
KP						
HE				3.116	0.902	6.308
CC						
RU						
NS						
KS						
CR						
LN						

For sample descriptions, see Table A-1.

Ref. No.	Sample No.	Ref. No.	Sample No.
80	KR 21-233	94	KR 23-273
87	KR 23-70	96	KR 23-288
91	KR 23-134	78	KR 21--173B

TABLE A-4. CONTINUED.

	Red-Brown & Brown Syenite	Nepheline Syenite				
Ref. No.	**143**	**51**	**52**	**59**	**60**	**72**
S.G.	2.73	2.64	2.71	2.67	2.70	2.66
AP	0.380	0.307	0.706	0.302	0.581	0.426
PO	0.056		0.056	0.027	0.055	
IL	1.457	0.754	0.944	0.609	1.160	0.504
OR	37.029	39.316	37.246	40.466	33.525	32.345
AB	38.859	25.408	27.851	25.042	42.753	31.736
AN	10.003	5.091	5.122	3.042	8.415	5.303
C						
AC						
MT	2.966	1.874	3.190	3.268	3.630	1.509
HM						
WO						
EN	0.936					
FS	3.415					
Q						
DI	0.824	0.652	2.280	1.805	1.256	1.409
FO	0.290	0.623	0.657	0.165	0.885	0.628
FA	1.165	3.285	1.575	0.471	1.823	1.798
NE		19.966	16.050	20.728	3.873	21.150
LC						
KP						
HE	2.621	2.722	4.324	4.076	2.045	3.192
CC						
RU						
NS						
KS						
CR						
LN						

For sample descriptions, see Table A-1.

Ref. No.	Sample No.	Ref. No.	Sample No.
143	KR 16-25	59	KR 16-97
51	KR 7-58	60	KR 16-99
52	KR 7-66	72	KR 21-107

TABLE A-4. CONTINUED.

	Nepheline Syenite					
Ref. No.	105	119	120	122	125	126
S.G.	2.63	2.70	2.67	2.67	2.69	2.69
AP	0.256	0.538	0.494	0.309	0.349	0.374
PO			0.028		0.028	
IL	0.286	1.034	0.731	0.700	0.686	0.900
OR	39.302	41.393	36.558	37.866	38.145	38.757
AB	28.068	37.634	38.742	34.060	31.966	37.096
AN	4.786	7.671	7.267	10.714		0.377
C				0.247		
AC					0.088	
MT	3.633	3.699	2.541	4.916	2.908	2.689
HM						
WO						
EN						
FS						
Q						
DI	0.600	1.721	1.246		1.865	2.227
FO	0.470	0.814	0.515	0.626	0.182	0.103
FA	1.349	1.176	1.239	1.176	0.728	0.366
NE	19.888	2.351	8.269	9.388	17.151	10.860
LC						
KP						
HE	1.363	1.969	2.371		5.905	6.251
CC						
RU						
NS						
KS						
CR						
LN						

For sample descriptions, see Table A-1.

Ref. No.	Sample No.	Ref. No.	Sample No.
105	KR 28-30	122	K26X-55
119	K25X-6B	125	K32X-7
120	K25X-40	126	K32X-14B

TABLE A-4. CONTINUED.

	Nepheline Syenite				Misc. Rocks	
Ref. No.	116	135	151	1153	115	83
S.G.	2.73	2.65	2.68	2.65	2.85	2.71
AP	0.723	0.260	0.260	0.256	0.875	0.515
PO		0.140	0.028		0.084	0.028
IL	0.592	0.717	0.657	0.782	0.542	0.767
OR	41.921	41.721	36.349	41.710	31.297	33.682
AB		29.422	29.311	27.388	18.977	41.489
AN		5.314	2.378	7.172	8.860	11.639
C						
AC	13.256					
MT		3.611	3.260	3.029	4.508	3.206
HM						
WO	7.590					
EN						
FS						
Q				0.00		
DI	1.563	0.774	1.290	0.567	1.731	1.582
FO		0.408	0.149	0.570	1.057	1.054
FA		1.021	0.825	2.259	6.826	1.506
NE	24.027	15.080	19.842	14.491	16.400	2.745
LC	0.040					
KP						
HE	8.771	1.532	5.652	1.777	8.844	1.788
CC						
RU						
NS	1.518					
KS						
CR						
LN						

For sample descriptions, see Table A-1.

Ref. No.	Sample No.	Ref. No.	Sample No.
116	K2D-68A	1153	K33X-32
135	KR 7-62	115	K2D-24B
151	KR 33-17	83	KR 22-122

TABLE A-5. AVERAGE CHEMICAL COMPOSITIONS* (WEIGHT PERCENT AND PPM) OF LITHOLOGIC UNITS FOR THE KILLALA LAKE ALKALIC ROCK COMPLEX.

	Gabbro Unit 4a,b,d (N = 23)		Larvikite Unit 4c (N = 3)	
	Mean	Std. Deviation	Mean	Std. Deviation
SiO_2	46.40	2.32	55.60	1.35
Al_2O_3	19.48	4.15	15.73	0.25
Fe_2O_3	3.55	2.95	5.50	2.59
FeO	6.03	2.79	5.46	2.35
MgO	6.04	2.20	1.17	0.13
CaO	12.52	1.55	4.32	0.30
Na_2O	3.14	0.68	5.22	0.30
K_2O	0.46	0.17	3.99	0.19
TiO_2	0.73	0.44	1.41	0.31
P_2O_5	0.49	0.33	0.44	0.04
MnO	0.13	0.05	0.24	0.00
CO_2	0.24	0.12	0.24	0.07
S	0.02	0.03	0.05	0.01
H_2O+	0.28	0.13	0.21	0.23
H_2O-	0.41	0.07	0.42	0.02
LOI	0.00	0.00	0.00	0.00
Total	99.93	0.58	100.00	0.40
Ag	<1.00	0.00	<1.00	0.00
Ba	232.61	72.19	1416.67	195.53
Co	45.22	19.86	8.33	2.89
Cr	82.83	85.77	<5.00	0.00
Cu	74.35	112.27	11.67	2.89
Li	8.78	8.55	5.00	0.00
Ni	63.26	31.39	<5.00	0.00
Pb	<9.13	4.17	<10.00	0.00
Zn	66.30	25.33	171.67	50.58
Be	<0.22	1.38	<1.00	0.00
Mo	<1.00	0.00	<1.00	0.00
Sc	16.87	7.39	23.33	2.89
Sr	734.78	222.81	433.33	57.74
V	105.43	75.75	<5.00	0.00
Y	<2.83	13.13	13.33	2.89
Ga	7.00	1.51	7.00	0.00
Nb	<10.00	0.00	5.00	25.98
Rb	<8.70	6.26	16.67	5.77
Zr	4.13	20.98	15.00	22.91
Sn	<1.00	0.00	<1.00	0.00
Eu				
Yb				
Ce	<500.00	0.00	<500.00	0.00
La	5.00	34.54	<10.00	0.00
Nd	<300.00	0.00	<300.00	0.00

*The average compositions may include duplicate samples or analyses which are not listed in Tables A-2 to A-4.

TABLE A-5 . CONTINUED.

	Monzonite Unit 5a,b (N = 8)		Buff Syenite Unit 6d,f,g (N = 32)	
	Mean	Std. Deviation	Mean	Std. Deviation
SiO_2	54.15	0.78	58.68	1.47
Al_2O_3	17.64	1.16	19.69	0.60
Fe_2O_3	3.64	2.33	1.19	0.49
FeO	5.06	2.13	3.02	0.73
MgO	1.87	0.68	0.58	0.19
CaO	4.68	1.15	3.06	0.43
Na_2O	5.35	0.96	5.91	0.82
K_2O	5.00	0.53	5.69	0.58
TiO_2	0.78	0.19	0.44	0.13
P_2O_5	0.47	0.14	0.22	0.06
MnO	0.23	0.03	0.12	0.03
CO_2	0.18	0.07	0.19	0.08
S	0.06	0.10	0.00	0.01
H_2O+	0.12	0.07	0.25	0.19
H_2O-	0.39	0.07	0.38	0.07
LOI	0.00	0.00	0.00	0.00
Total	99.59	0.47	99.46	0.63
Ag	<1.00	0.00	<1.00	0.00
Ba	626.25	231.94	1582.81	563.17
Co	14.37	8.21	<1.03	5.72
Cr	11.12	7.38	<4.66	1.94
Cu	18.12	5.94	5.41	3.20
Li	7.75	2.38	11.37	9.28
Ni	3.50	7.71	<5.00	0.00
Pb	<1.62	11.61	4.69	15.30
Zn	124.87	6.98	74.09	19.72
Be	4.00	0.53	2.62	1.66
Mo	<1.00	0.00	<1.00	0.00
Sc	8.37	5.78	2.44	6.42
Sr	331.25	88.39	540.62	131.64
V	33.75	18.85	<5.00	6.35
Y	31.87	9.98	16.87	14.69
Ga	10.50	2.83	8.87	3.05
Nb	123.75	28.25	99.53	64.76
Rb	63.75	23.87	74.06	38.00
Zr	218.75	37.20	138.44	123.18
Sn	<1.50	0.93	<1.69	0.97
Eu	<100.00	0.00	<100.00	0.00
Yb	2.00	1.41	0.18	1.40
Ce	<338.75	300.59	<285.31	307.04
La	16.87	72.75	0.94	72.17
Nd	<218.75	164.62	<215.62	131.64

TABLE A-5 . CONTINUED.

	Red-Brown & Brown Syenite Unit 6j,e (N = 28)		Nepheline Syenite Unit 6h,i,n (N = 16)		Misc. Rocks (N = 2)	
	Mean	Std. Deviation	Mean	Std. Deviation	Mean	Std. Deviation
SiO_2	57.98	1.97	56.46	2.17	54.70	5.52
Al_2O_3	19.00	1.58	19.45	1.77	18.75	0.78
Fe_2O_3	1.92	0.78	2.42	0.95	2.62	0.61
FeO	3.76	1.81	2.91	0.48	5.70	4.10
MgO	0.96	0.61	0.48	0.17	0.90	0.01
CaO	3.29	0.68	2.76	1.40	4.03	0.86
Na_2O	5.17	0.63	6.89	0.86	5.58	0.18
K_2O	5.74	0.91	6.44	0.48	5.41	0.32
TiO_2	0.58	0.26	0.38	0.11	0.34	0.08
P_2O_5	0.29	0.17	0.18	0.07	0.30	0.11
MnO	0.15	0.06	0.19	0.06	0.22	0.13
CO_2	0.21	0.08	0.51	0.67	0.12	0.04
S	0.04	0.10	0.00	0.02	0.02	0.01
H_2O+	0.25	0.16	0.39	0.38	0.41	0.25
H_2O-	0.44	0.09	0.40	0.07	0.37	0.08
LOI	0.00	0.00	0.00	0.00	0.00	0.00
Total	99.80	0.81	99.89	0.69	99.50	0.28
Ag	<1.00	0.00	<1.00	0.00	<1.00	0.00
Ba	1070.00	490.65	537.50	410.34	1470.00	806.10
Co	3.50	7.24	0.69	5.19	10.00	7.07
Cr	<2.50	9.18	<4.06	3.75	<5.00	0.00
Cu	7.93	6.65	2.12	5.92	17.50	10.61
Li	13.14	5.99	11.56	3.60	6.50	4.95
Ni	<4.29	2.62	<5.00	0.00	<5.00	0.00
Pb	1.14	15.13	4.44	20.96	<10.00	0.00
Zn	85.57	36.36	105.06	56.23	72.50	10.61
Be	1.61	1.97	4.56	4.29	1.50	3.54
Mo	<1.00	0.00	<1.00	0.00	<1.00	0.00
Sc	5.07	8.45	2.87	6.79	<5.00	0.00
Sr	517.86	223.28	308.12	220.88	1050.00	636.40
V	5.18	20.84	0.00	13.54	<5.00	0.00
Y	22.32	18.03	22.19	10.48	17.50	3.54
Ga	9.82	2.75	9.12	4.81	5.00	1.41
Nb	76.96	80.51	170.00	156.88	150.00	0.00
Rb	65.36	27.55	101.25	34.81	80.00	28.28
Zr	172.50	364.00	1368.00	3369.56	140.00	84.85
Sn	<1.57	0.92	<1.06	1.29	<1.00	0.00
Eu	<100.00	0.00	<100.00	0.00		
Yb	0.62	2.56	0.67	1.53		
Ce	<294.64	355.83	<375.62	267.46	<500.00	0.00
La	10.71	72.66	0.94	55.17	7.50	24.75
Nd	<223.21	141.08	<262.50	80.62	<300.00	0.00

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